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UNITED STATES DEPARTMENT OF THE INTERIOR
Douglas McKay, Secretary

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THE PROGRESSIVE FISH-CULTURIST

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A CENTURY OF AMERICAN FISH CULTURE, 1853-1953

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"IT SHOULD NOT BE SURPRISING that the subject [fish culture] is attracting the attention of some of the best minds in our country; more especially when we consider the impoverished condition of our rivers and streams, many of which are susceptible of being inhabited by innumerable salmon and trout, and since a replenishment is now no longer problematical," wrote Dr. Theodatus Garlick as he described his first experiments of 1853 (Garlick 1857).^{1/}

Since Dr. Garlick's optimistic words were recorded, fish culture has been absorbed into the expanding science of fishery management. Ten decades of changing viewpoints, vanishing species, and conservation triumphs have molded our profession beyond the fondest dreams of Dr. Garlick. Centennials are traditionally years of recapitulation and prophecy. It is hoped that the brief historical review which follows will stimulate a vitalized consideration of the similarity of our problems today to those which have occupied our predecessors' minds for the last 100 years. By plotting their points of progress, perhaps we can enlighten, coordinate, and expedite our own contributions to the future.

THE FIRST FIFTY YEARS

Garlick's initial experiments caught the immediate interest of a young and growing country. Several individuals repeated his successes, and a number of commercial hatcheries appeared soon after the opening of Seth Green's in 1864. During the following 20 years, however, there was little official

^{1/}In 1855, 2 years after Garlick's experiments, the Rev. Dr. John Bachman of Charleston, S. C., claimed to have hatched trout eggs as early as 1804. His claims are credited by some, discredited by others, but his labors had little or no influence in developing interest in the art (U. S. Com. Fish. Report, 1872-73 [1874], p. xxiv; also appendix by Milner, p. 533).

recognition of this new-found science. The depletion of sea fishes was first brought to official attention in Rhode Island and Massachusetts in 1870. Special legislative committees from these States met to consider the decline of fishing on a joint fishing ground. At this point there was set a precedent which was followed by fishery investigations for many years: Rhode Island declared the decline to be of serious extent and recommended restrictive measures; Massachusetts took the opposite viewpoint. Situations like this were further typified by the Connecticut River, where four States had controlling interests which could not be coordinated.

Eventually popular request for intervention by the United States Government resulted in a bill to appoint a fish commission to determine "whether any and what diminution in the number of the food-fishes of the coast and the lakes of the United States has taken place ..." The bill became law on February 9, 1871 (U. S. Com. Fish. Report, 1871-72 [1873]: xi).

The results of the first 2 years' investigations substantiated the reports of decrease in marine fisheries. It is interesting to note that the basic diagnosis as to the cause (overfishing) and the remedy (controlled methods of take) remain essentially unchanged today. But the sequence of events in the 80 years from then until now has not always followed the path of logic.

The American Fish-Culturists' Association, the predecessor of our American Fisheries Society, is given full credit for the next great development in our management history. In 1872, at the urging of this organization, Congress enlarged the duties of the Fish Commission to include the propagation of fish (U. S. Com. Fish. Report, 1872-73 [1874]: xxxiv). For many years, marine investigations and artificial propagation were the sole major functions of the Fish Commission.

The years which followed were filled with epoch-forming developments. Livingstone Stone

undertook collection of "California Salmon" eggs, which were distributed in practically every eastern stream. An attempt was made (1873) to transfer Atlantic-slope fishes to the Pacific slope in the first railroad aquarium car. (The car was ingeniously and completely fitted in every detail and contained 300,000 fishes of 10 species, but the experiment was terminated when the car jumped the tracks over the Elkhorn River of Nebraska.) Carp were introduced from Europe and distributed throughout the country as the panacea to the food-fish problem (1877). Striped bass and shad were introduced successfully in west-coast waters. Rainbow trout were sent to the East (1880), oysters were propagated (1881), brown trout were imported from Europe (1883), and brook trout were introduced into the West.

Long before 1900, however, it was evident that troubled waters lay ahead. As early as 1877 there was some public dissatisfaction with the progress of repletion (U. S. Com. Fish. Report, 1877 [1879]: 18). In the first 10 years, the subjects of pollution, overfishing, dams, and fishways were beginning to assume importance. By 1888 the first admission of complete failure in a major phase of fish culture appeared. Millions of eggs of the Pacific salmon had been transferred to the eastern stations, hatched out, and the fry planted in nearly every one of the rivers south of the Hudson. In no single case did the experiment prove satisfactory, and the Commissioner was forced reluctantly to abandon the project (U. S. Com. Fish. Report, 1888 [1892]: xxxv). In 1894, in a discussion of the Great Lakes fisheries (Smith 1894: 458), the following statement appeared: "The foregoing comparative statistics of the products of the fisheries shows that in nearly every lake the catch of whitefish--the species having the greatest interest to fish-culturists--has decreased since 1885. No well-informed person, however, will argue from this that fish-culture in the Great Lakes is a failure."

The above statement shows clearly the one strong issue which was relatively uncontested for more than 70 years and which has been the foundation of fishery management for an even longer period. There can be little wonder that this unbounded enthusiasm for artificial propagation engulfed the country. In a short span of 20 years, the United States assumed world leadership in the profession. Our first Commissioner, Spencer Baird, was named the world's leading fish culturist at the Berlin International Exhibition of 1880 (Goode 1883: 62). The results of fish culture

were everywhere available. Atlantic salmon were recovered in rivers where these fish had been planted 4 to 5 years earlier as far south as the Susquehanna. Shad appeared in the Sacramento and Ohio Rivers (U. S. Com. Fish. Report, 1878 [1880]: xxxviii). By 1887, rainbow trout were doing so well at the eastern fish-cultural stations that western shipments were discontinued (U. S. Com. Fish. Report, 1887 [1891]: xviii). By 1896, this species had been successfully acclimatized in almost every State east of the Rocky Mountains (Smith 1898: 137). The initial plants of shad and striped bass in California yielded more than 7 hundred thousand pounds of the former and more than 50 thousand pounds of the latter to the commercial fisheries by 1893 (Wilcox 1895: 146). There is little question that the failures of fish culture have received less attention than the successes, but the terrific impact of artificial propagation on our fish populations and their distribution can hardly be minimized.

During this same period, a new field of science was developing--a field which was eventually to question the supremacy of artificial propagation as a conservation tool. Our research and investigative branches have grown from many small beginnings. It is surprising, however, to note the questions for which investigators were seeking answers long before our times. As long ago as 1879, one of the foremost nutritionists, A. W. Atwater, was investigating the chemical composition of fish (U. S. Com. Fish. Report, 1879 [1882]: xix). By 1880, marine investigational work and the collection of statistical data were far advanced. In 1881, one of the first changes in stocking procedure was noted: instead of planting fish in a great many different streams, the Commission began a policy of stocking a few streams with a great many fish in the hope that better results would be obtained (U. S. Com. Fish. Report, 1881 [1884]: xiv). The field of fish technology was opened in 1879 with investigations on methods for freezing fish, and in 1882 net preservatives were being studied. The Woods Hole Laboratories were established on a permanent basis in 1882 (U. S. Com. Fish. Report, 1882 [1884]: xviii). The first of many spawntaking experiments was described in 1884 (U. S. Com. Fish. Report, 1884 [1886]: xxxii). One of the first reported occurrences of the "red tide" was recorded in 1884 (U. S. Com. Fish. Report, 1884 [1886]: xlii). In this year also appeared the following words: "It cannot be often enough repeated that not every kind of fish thrives in every water, and that we can expect success in fish-culture only when

we put the right fish into the right water."--Borne, 1884.

By 1886, almost 70 years ago, the value of raising larger fish was recognized and put into practice. In that year the station at Wytheville, Virginia, was raising rainbow trout to 5 and 6 inches in length for stocking (McDonald 1889: 799-800). This may come as a surprise to those of us who consider "legal" stocking as a modern innovation. The following official statement was made in 1888: "The often inadequate and disappointing results from stocking with the fry of trout and salmon has led to this new departure [stocking with yearlings]."--U. S. Com. Fish. Report, 1888 [1892]: xx. By 1892, reports were appearing on nutrition experiments, 'especially those utilizing various dry feeds such as wheat "shorts" (U. S. Com. Fish. Report, 1892 [1894]: 1111).

A paper entitled "Biological Research in Relation to Fisheries" appeared in 1893 (Ryder 1893), and by 1897 studies of the movements, habits, food, growth, etc., of young fish were well in progress to aid in better propagation practices. In this year also appeared "A Manual of Fish Culture" (U. S. Com. Fish. Report, 1897 [1898]: 1-340). Although printed almost 60 years ago, this is still the most complete text on the subject. In the following year one of the first recommendations to Congress for a permanently appointed fish pathologist was made. A German (Hoffbauer 1898) rediscovered the principle of age determination by counting the annuli or annual growth increments on the scales. The following prophetic statement came from New York: "The greatest enemy of the fish of Cayuga Lake, New York, is a fish-like animal commonly known as the lake lamprey or lamprey eel."--Surface, 1898. Each of these slight beginnings has developed into a major field of activity in fishery management and fishery research. Many of our fundamental concepts and policies today can trace their origins to pioneer work which was started and advanced to a considerable extent before 1900.

THE SECOND FIFTY YEARS

Since 1900, two outstanding forces have influenced our profession's development. Changing social and economic conditions have given the American people an undreamed-of mobility. This, combined with an increase in leisure time, has produced an overwhelming increase in fishing pressure. The result has been an almost complete change in emphasis upon fishery management programs of inland waters. Previous to 1900, the basic goal was

to increase the food potential of American waters. The factors of recreation and sport fishing were recognized but were considered of insignificant importance. Today, in contrast, the primary consideration is sport fishing and every effort is being made to minimize the food aspect. These radical changes in both our economy and our concepts of fishery management have necessitated a sound research program. Facts to support the fishery programs in practice, facts to justify changes in fishery management, facts to maintain a portion of our heritage: these are the objectives of present-day research. An examination of these last 50 years of "progress" may shed some light on the next 50.

The first half of the history of our fish culture was dominated entirely by the practices of artificial propagation. A review of the literature will reveal the perhaps startling fact that our policies to date in the 20th century have been almost equally so dominated. In addition, the trends for the future appear to place an even greater dependence on artificial propagation than at any time in the 100 years of our history, especially in the field of sport fishing.

COMMERCIAL FISHERIES

There has been one major exception to the continued swing toward artificial propagation. In the field of commercial fisheries, both marine and inland, an almost complete reversal has taken place. At the inception of the original Fish Commission, propagation of commercial species was of the highest importance. In 1899, the total Federal production of eggs, fry, and fish exceeded 1 billion for the first time (U. S. Com. Fish. Report, 1899 [1900]: xxxv). Thereafter, total hatchery production spiraled continually upward. Since 1900, however, there has been an increasing amount of controversy between public opinion and the logic based upon a growing number of biological investigations on the effects of artificial propagation. Though the one factor singularly influential in fishery administration has been public opinion, the influence of both groups is apparent in the development of our present policies.

In 1923 there appeared one of the first official statements which was indicative of the thinking of the professional fishery biologists:

The correction of existing and the prevention of prospective depletion has been sought principally through the agency of fish culture and legislation more or less restrictive of

fishing operations and practice. It is obvious that a foundation for these measures must be established on an accurate and reasonably complete knowledge of the life histories of the organisms with which they deal, as otherwise they may prove wasteful and ineffective while at the same time imposing futile obstacles to the development of a legitimate and essential industry.--U. S. Com. Fish.

Report, 1923 [1924]: 15.

By this time, production from fish hatcheries was around 5 billions and public pressure was forcing it still higher.

That the crack in this solid front was opened only with great difficulty is shown by the reiteration of policy which came only a year later. "The most important fish-cultural operations of the Bureau are those relating to the maintenance of the commercial fisheries..."--U. S. Com. Fish. Report, 1924 [1925]: xv. In the next year, however, one of the first open breaks with this policy was reported from the Great Lakes, where the controversy had been increasing for at least 20 years. Walter Koelz wrote:

At this point it is only fair to state that the leading fish-culturists now regard artificial propagation rather as a supplement to than as an improved substitute for nature ...

No one may safely affirm that the relatively few eggs that are artificially hatched--few in comparison with the numbers destroyed in the effort to collect them--can compensate for the benefits that might be derived if all the fish were allowed to spawn naturally.

The closed season to protect spawning fish should be restored wherever practicable, and no spawn should be collected if investigations and experiments fail to establish the desirability and effectiveness of propagation. --Koelz 1926: 614-617.

In the next 3 years, opposition to this policy had taken hatchery production up to the 7-billion mark (U. S. Com. Fish. Report, 1928 [1929]: 11).

In 1934, "the commercial fisheries are to a large extent supported by natural reproduction, hence emphasis was placed upon the propagation and distribution of those forms which are required to maintain good fishing in the public domain ..." (U. S. Com. Fish. Report, 1934 [1936]: 96-97). But 3 years

later it was reported, although somewhat apologetically, that "largely because of low unit cost of production and the fact that the salvaging of eggs from commercial fishing boats represents a byproduct recovery, greater attention has been given to the propagation of strictly marine species."--U. S. Com. Fish. Report, 1937 [1939]: 91. In 1936, another significant study was contributed from the Great Lakes. By comparing known quantities of fry planted in different years with fluctuations in the abundance of yellow pikeperch, Hile (1937) found it impossible to correlate an observed increase with the effects of artificial propagation. Production exceeded 8 billions at this period, but the turning point had been reached.

The issues at stake in this controversy are basic to the very survival of our profession as such. It is fortunate, indeed, that our predecessors and colleagues have been successful in bringing this portion of the industry to the brink of management based on fact-finding programs. The task is by no means completed. In 1950--THREE YEARS AGO--for the first time in 51 years, production of eggs, fry, and fish fell below the 1-billion mark, thus indicating the end of an epic era.

These billions were produced for the record. More than 99 percent consisted of eggs or newly hatched sac fry. It is generally acknowledged that their production had little or no effect on the marine fisheries, and today the practice has been practically abandoned. However, the emphasis placed on this program was so great that the public has been completely sold on the value of artificial propagation. Modern management programs meet no greater handicap than this solid wall of public opinion, which still almost unwaveringly supports "production by the billions."

The Great Lakes investigations have received an additional setback which may yet revive the advocates of artificial propagation as applied to commercial fisheries. With the construction of the Welland Canal, the sea lamprey was able to bypass insurmountable Niagara Falls and gain entrance to the Great Lakes. By 1936, this parasite had been recorded in Lake Michigan (Hubbs and Pope 1937). The total destruction of the commercial fisheries appears now to hinge on the success of control measures. It is to be hoped that the present decline is assessed to the lamprey, not to cessation of artificial propagation.

GAME FISHERIES

The development of sport or game fisheries has not followed a clear-cut path. Intensive

progress has been limited to the last 50 years. A great diversity of economical and biological conditions has created an equally diverse set of opinions on the future of game-fisheries management. A review of this development seems particularly pertinent.

After 1900, biological studies received increasing support. This was no doubt due to the increased value placed on sport fishing. California, as early as 1924, issued 200,000 angling licenses, a number equal to the number of persons engaged in the commercial fisheries of the entire United States and Alaska (U. S. Com. Fish. Report, 1924 [1925]: x111). It was estimated in 1931 that more than 25 million dollars' worth of fishing tackle had been manufactured (U. S. Com. Fish. Report, 1931 [1932]: 11). By 1945, the capitalized value of the sport fishing industry was estimated at 5.0 billion dollars, whereas the entire commercial fisheries was evaluated at only 5.8 billion dollars (U. S. D. I. Secretary's Report, 1945: 181).

Investigators from many specialized fields have been utilized in the research background of our game-fish programs. Work in fish culture, *per se*, considerably antedates the biological-environmental type of study, though in both fields the greatest advance has been made in the period since 1920 and particularly since 1930. An American university first established a department of fisheries in 1919 (Cobb 1928). Since that time the University of Washington has been joined by many other universities and colleges which have attempted to train professional fishery biologists to guide the future of fishery management. As Huntsman (1930) pointed out, the old type of observational biology was not sufficient, although for many years colleges had been contributing men who were qualified for little else. In 1940 the U. S. Fish and Wildlife Service sponsored a survey to determine what academic qualifications experienced fishery biologists considered necessary for the profession. The response emphasized the desirability of additional technical training in fields of science allied with biology. Thus organic and physiological chemistry, including qualitative and quantitative analysis, were considered essential or desirable by more than 75 percent of those interviewed; statistics was rated essential by 100 percent; histology, micro-techniques, business administration, logic, nutrition, and advanced physiology were recommended by all (Deason 1941). The result has been an encouraging improvement in the college product, though the necessity for continued advance in this field is still apparent.

By 1901 the Bureau of Fisheries was employing one pathologist on a nearly full-time basis, and in 1911 there was a strong recommendation in the Commissioner's report for the establishment of an experimental station for the study of fish diseases (U. S. Com. Fish. Report, 1911 [1913]: 67). In 1915, Congress finally approved appointment of a fish pathologist as a member of the regular scientific personnel of the Bureau. The most complete work available on fish diseases is H. S. Davis' "Care and Diseases of Trout," which appeared for the first time in 1929. Marsh, Davis, and Emmeline Moore are among the pioneers in this field.

Nutritional research is somewhat more recent than the first directed disease investigations. Though many "experiments" are available in the literature, there are few controlled investigations which date earlier than 1923. At that time rather preliminary vitamin studies were made by Davis and James (1924) at Manchester, Iowa. Before 1930, McCay and Titcomb had contributed papers (McCay et al. 1927, Titcomb et al. 1929) dealing with the basic nutritional requirements of trout.

In 1932, C. F. Culler, in an article entitled "Progress in Fish Culture," asked the question: "How much advancement has been made in the cardinal processes of fish culture?" After a review of 50 years of progress, he was forced to conclude that advances had not been outstanding. It was perhaps coincidental that his question came on the eve of a new era in fish-cultural research. In that same year the long-sought experimental station for the study of fish diseases was established at Leetown, West Virginia (U. S. Com. Fish. Report, 1932 [1933]: xx111). In 1933, a co-operative project undertaken by Cornell University, New York State, and the Federal Government resulted in an experimental laboratory for the investigation of fish nutrition at Cortland, New York. Davis, Gutsell, and Snieszko in the West Virginia station; McCay, Tunison, and Phillips at Cortland; and Fish and Rucker on the west coast have advanced our understanding of basic fish physiology and pathology by great degrees in the last 20 years. Major accomplishments of these and many other workers include the development of diagnostic methods and successful treatment for furunculosis with sulfonamides and for ulcer disease with antibiotics, the development and use of feeding charts, the determination of vitamin requirements, the elimination of certain deficiency diseases, the control

of gill disease with pyridylmercuric acetate (Van Horn and Katz 1946, Rucker 1948), the initial development of a synthetic diet (Wolf 1951), investigations in salmon feeding problems (Donaldson and Foster 1939, 1941), the use of formalin for the treatment of external parasites (Fish 1940, 1947; Fish and Burrows 1940), and a host of lesser accomplishments.

Work in the field of genetics has never received the attention which it appears to merit. Various studies are recorded for the development of faster-growing strains, better egg producers, earlier spawners, and disease-resistant varieties (Embrey and Hayford 1925, Davis 1934). Few, if any, extended and well-controlled studies are available, however. A series of experiments in the State of Washington indicated that selection for early maturity so retarded growth that the program was terminated (Millenbach 1950). Several observers have posed the possibility of breeding a nonmigratory strain of rainbow trout, but the program has not yielded positive results to date (Carbine 1953).

Development of salmon culture has differed sufficiently from trout culture to merit individual attention. Since the production of an adult-sized fish is not feasible, efforts have been directed to improving the production of fry and fingerlings. Fry of certain species are still planted in significant numbers. The value of such work should be fully evaluated. Emphasis has been placed in later years on the production of larger fingerlings. The success in the rehabilitation of the Lower Columbia salmon runs seems to favor such methods. An interesting comparison is available in the Alaskan fisheries, where management has emphasized, in contrast to artificial propagation, a sufficient escapement of the total population to insure natural perpetuation of the species. The fish pack in Alaska is apparently continuing to decline.

Warm-water fish culture has attained a unique position. After decades of intensive artificial propagation and stocking, most conservation agencies have made a complete reversal in policy. Present recommendations almost universally call for a complete halt to the stocking of natural waters. It is generally recognized that today's major problem is one of overpopulation. The corrective trends emphasize removal of all restrictive regulations, use of selective poisoning, introduction of predator species, and--where possible in extreme cases--draining.

Culture of warm-water species is still of considerable importance, however, for stocking the vast number of farm fishponds which are constructed each year. The farm pond was

in great demand by 1914. In the last 20 years, literally hundreds of thousands have been constructed. By January 1952, it was estimated that there were 1,666,000 farm and ranch ponds in existence (Compton 1952). This particular phase of fisheries management is characterized by many concepts which make it a distinct field. The farm pond initially evolved as a method of increasing the food supply. Though this purpose is still important, the aspects of recreation and sport fishing have had an important effect on management trends. The opportunities for closely controlled conditions of fertility, stocking ratios, fishing pressures, etc., have made this an ideal field for study. Swingle in Alabama has contributed greatly to our knowledge of farm pond management. The great variations in growing seasons between our northern and southern boundaries, however, leave much to be developed for widespread successful management.

FISH MANAGEMENT

In the entire profession of fishery management, there are few more controversial questions than those arising from what may be termed the biological-environmental field of investigation. It is doubtful whether unanimous opinion exists on any single principal which has been developed in this field.

Biological investigations are as old as the profession of fishery management. Originally, the field was developed when the sharper minds among our predecessors realized that artificial propagation was not an end in itself. It early became apparent that stocking fish could be successful only if it was done in harmony with biological information concerning the habitat. Since artificial propagation met with such universal acceptance, however, it was not until well after 1900--when deficiencies became apparent--that biological investigations received their greatest impetus. From the very outset there have been two almost completely separate classes of investigators. One class has directed research to achieve better utilization of the hatchery product. The other has sought the same objective of better fishing through improvement of the habitat and natural reproduction. That the two types of investigations should complement each other to perfection is apparent. The cases in which they have done so are rare.

It was realized long before 1900 that better survival was obtained with larger fish. General acceptance of this principle, however, was not reached until late in the 1920's,

when most agencies had discontinued egg and fry stocking except in special waters. Since that time there has been a gradual transition to a policy of stocking legal-sized trout only. In the 1930's several workers began to place emphasis on the futility of fall stocking of any kind because of the heavy overwinter mortality. As a direct result, management programs today have reverted largely to distribution schedules in the spring and summer. Thus was born a new term, "put-and-take fishing."

With the acceptance of this new management tool, there has developed a controversy which will influence every principle which has been proposed as basic to the foundation of fishery biology and fishery management as a science. This controversy began 20 years ago. It has not yet reached its peak proportions, and there is every indication that its eventual culmination will be the most important point in the next 100 years of our history. Put-and-take fishing, when developed to its ultimate, involves no overwinter survival. There need be no consideration of habitat, carrying capacity, food gradients, etc. The most essential measurement is the potential fishing pressure of a given area over a given period. The proper number of fish are then "put" to meet the estimated "take." This appears contrary to the basic concepts from which fishery management has evolved. A brief review of the sequence of events leading to this situation should prove of interest.

In 1924, Kendall wrote one of the first comprehensive reviews of the status of fishery management. It was apparent at that time that indiscriminate stocking was inimical rather than beneficial to continued game fishing. The thesis of his entire review could be summarized by a quotation from Evermann and Clark (1920): "No stream or lake should be stocked with fish until it has been carefully studied by a competent biologist and found to possess the conditions or factors of favorable environment for the fish which it is proposed to introduce."

The course which these biological investigations took is well described by Belding (1926): "... by comparing the natural conditions in the productive and unproductive lakes, it was possible to determine the factors both favorable and unfavorable for the existence of several species." It is of importance to note that the criteria which were used in these early days consisted of such characteristics as area, depth, turbidity, vegetation, and food. Emmeline Moore (1926) further characterized stream surveys thus: "... the chief objective is ... the

attainment of a more intelligent stocking policy ... the data sought ... including a first hand study of the stream, its character and condition, the temperature, the food supply, the fish population, pollutional conditions, etc."

By 1927, Embury's stocking table was available. Stream gradients, size, flow, food abundance, etc., were utilized (Embury 1927). It was one of the first quantitative stocking tables and was widely utilized. In the following year the Cultus Lake investigations were started (Foerster 1928). This study was the forerunner of several ideally controlled experimental areas which were markedly to influence future policies. In 1930 the Michigan Institute for Fisheries Research was created (Hubbs 1930). In this year also there appeared a statement which is as pertinent today as it was then:

The old type of observational biology is not sufficient, though of primary importance. Associated with it there needs to be ecology, physiology, biochemistry, chemistry, and physics. Every effort should be made to awaken the interest and enlist the services of specialists in these fields. Also constantly the investigations should be started from the standpoint of application to the needs of the fisheries ... --Huntsman, 1930.

Among the first results from Cultus Lake was evidence of markedly better survival from propagation with larger fish (Foerster 1931). A year later a most encouraging statement was made by an experienced midwestern fish-culturist: "... the ultimate objective of fish culture is to maintain and increase the supply of fishes in open waters as well as in the hatchery."--Culler, 1932.

In 1933, Seth Gordon was one of the leaders in a movement which was to become progressively more critical of fishery management. In that year he wrote, "Notwithstanding our annual expenditure of about \$5,000,000 in the United States for fish-cultural work, we have failed miserably when it comes to developing a scientific research and management program which would assure the wise use of the fish so produced." Three years later Hubbs was somewhat more emphatic:

It is being realized that the well-meaning efforts of the past have been to a large degree haphazard, incomplete, imperfect, uncoordinated, non-technical and untested. ... Almost no adequate tests have been made of the results of the artificial propagation of any species, either in specific

waters or in general. ... Though stream and lake improvement has become popular and extensively practiced, very little attention is devoted to testing the benefits resulting from this new line of fisheries work. ...

--Hubbs, 1937.

One of the true signs of our times appeared in 1938. In "A Program for the Management of Fish Resources in Great Smoky Mountains National Park," Willis King (1939) described one of the first intensive management projects where close supervision and regulation were combined with limited stocking. This work contained an early suggestion for spring stocking. In Michigan at the same time, experiments were reported which indicated that heavy stocking during the fishing season might increase the catch of wild fish and thus deplete the resident population (Hazzard and Shetter 1939). In the Commissioner's report for the year (U. S. Com. Fish. Report, 1938 [1940]: 118), this statement appeared:

Although the yearly output of fresh-water game fishes by State and Federal hatcheries amounts to several billion young fish, it is generally recognized that a commensurate return is not being realized by the several million anglers who seek sport in the Nation's streams. The conclusion is inescapable that some, at least, of the hatchery output is being wasted by being planted under conditions which do not favor survival. ...

Davis (1939) wrote of management as follows: "... the primary purpose of management of our trout streams is to produce satisfactory fishing for the largest possible number of anglers at a reasonable cost. ... Our management plans, therefore, must be developed to provide sport rather than food, ..."

A new management tool, rotenone, was developed at this time (Leonard 1939). In the last 10 years particularly, rotenone has been used with increasing effectiveness in all parts of the country. Reclaimed lakes have been especially helpful in maintaining natural fishing. Another extremely important management tool was used for the first time in 1939. Haskell of New York reported (1940) the first experiments with the electric shocker in this country. Development has been rapid, and most critical stream studies today utilize electricity in some form for census work.

Studies from Vermont at this time indicated that under certain conditions natural propagation was superior to artificial in maintaining a stock of trout and emphasized the necessity of regulating planting operations

in accordance with the amount of natural food in the stream (U. S. Com. Fish. Report, 1939 [1941]: 63). The subject of put-and-take fishing was being met openly by 1940. A widespread viewpoint was aptly expressed by the New York Commissioner of Conservation when he said:

Personally I haven't much use for it. I don't believe you have either. It is no true substitute for the genuine article. Is it necessary in New York to abandon true trout fishing for a third rate substitute ... ?

--Osborne, 1941.

Another milestone of management progress was reported by Chamberlain when he described (1943) the Pisgah studies. This work represents one of the strongest arguments for spring stocking, legal-sized plants. It combines intensive management with stocking programs much as earlier described by Willis King but is carried an additional step forward in that much more accurate measurement is made of fishing pressure and take.

Another study made in 1943 indicated that planted fish contribute only a minor portion of the catch (Smith and Smith 1945). This study also found a survival of brown trout planted in the fall comparable to survival of those planted in the spring. Trembley (1945) repeated this observation for all three species of trout under mild winter conditions, and Shetter (1947) noted that fall stocking of brown trout may be as successful as spring stocking under some conditions. This report also included an excellent summary of results from experiments made to test fall and spring stocking. The positive results from spring stocking were far in the majority.

A very significant occurrence in 1944 was the establishment by the Fish and Wildlife Service of a section within the Division of Game-Fish and Hatcheries for the application of management principles to Federal stocking (U. S. D. I., Secretary's Report, 1944: 187). The distribution of Federal fish has been accomplished almost entirely by the application system. The number of such applications has ranged from 287 in 1873-76 (U. S. Com. Fish. Report, 1875-76 [1878]: 9) to more than 50,000 in 1951 (Duncan 1951). In the earlier days it was necessary only to have an application signed by a Senator or Congressman and the fish were then stocked. In later periods cooperative agreements were arranged with State administrations to prevent duplications and introductions of harmful species. In more recent years the stocking of Federal waters has followed the current management trends.

It is pertinent to ask now, what are the current management trends? It is apparent that little general agreement on stocking policies exists, and that a very wide diversity of results has evolved from the various investigations reported. What are the reasons for this lack of harmony, and is there any possibility of compromise? Shall we continue to have wild trout fishing, or shall we rely completely on put-and-take management?

There appear to be at least two major reasons for the present condition of our sport fisheries. One is the continued increase in fishing pressure. The other is the failure of our technological fish-cultural methods to keep pace with the changing requirements of the management programs.

The increase in fishing pressure cannot be curtailed. Around centers of great population density it seems impossible to maintain so-called wild trout fishing. Fortunately, these are special situations. The knowledge that put-and-take fishing must be used in these areas should not influence management programs in other, more extensive and less heavily fished areas. Our growing population is sometimes viewed with the grim prophecy that all of our country will be overcrowded. Eventually such a condition may arise, but throughout our industrial East at the present time there are numerous areas which lie within 100 miles of our greatest centers of population yet are relatively untrampled. It is well established that a great portion of the increased fishing public is not proficient at angling. This segment of the fishing public wants fish in any form, and it is to this type of fisherman that put-and-take programs will have greatest appeal. At the same time, the majority of these individuals do not care sufficiently for fishing to drive 100 miles or walk 5 miles to obtain it. This fact may well preserve our wild fishing. The fisherman who will travel such distances will not be appeased by put-and-take fishing. It is for this individual that we must preserve our wild fishing. Both techniques have a definite application, however, and generally they can best be utilized together. An excellent review on recent advances in fishery management has been prepared by Eschmeyer (1949).

Fish-cultural methods apparently have not developed at the same rate as biological-environmental investigations. There are numerous papers in which hatchery fish and wild fish are compared. It should be interesting, however, to review a few of the more critical studies. The earliest of these were by Marsh (1902) and Marsh and Gorham (1906), who pointed out that hatchery fish had lower

erythrocyte counts and hemoglobin levels than wild trout. These experiments, like practically all others on this subject, show a remarkable omission. There is no accurate description of the conditions under which the hatchery fish were raised. For this reason it is almost impossible to reach any valid conclusions concerning the effect of hatchery methods by comparing the results of different investigations. Another early critic of hatchery methods was Hewitt, who showed, both by chemical (1937a) and by histological analysis, that hatchery fish developed an abnormal fatty degeneration of the liver. He wrote (1937b): "Fry fed as they are usually fed in hatcheries ... develop fatty livers almost at once and are not normal fish after the first month of feeding." Hewitt considered this condition the principal cause of poor survival of hatchery fish. Another investigator who utilized histological techniques described extensive fatty degeneration of the pancreas of hatchery fish (Hess 1935). Klak (1941) stated:

Evidence has been presented that hatchery trout planted as fingerlings and examined later as adults were not so well adapted to the food situation in the stream environment as were the native trout. ... It was demonstrated further that adult hatchery trout planted for immediate removal suffered a loss of condition during the fishing season.

Williamson and Schneberger (1943) reported, from a legal-sized stocking experiment in Wisconsin, that stocked fish were inferior in condition and sporting value. The survival of hatchery fingerlings was shown by Schuck (1945) to be inferior to that of wild fingerlings. This author contributed a significant review on the inferiority of hatchery trout to wild trout and offered comprehensive suggestions for a research program to correct the condition (Schuck 1948). Little response has been evident. Smith and Needham (1942) wrote, "Selective breeding of trout has already increased the possibilities of hatchery production, but the adaptability of domestic strains to hatchery life does not necessarily prove their offspring will be equally suited to stream life." Studies from Convict Creek showed wild brown trout growing almost twice as fast as planted rainbow trout (Needham and Slater 1945). This is contrary to the condition which exists in hatcheries, where rainbow trout are the faster growing of the two species.

A subject of great debate has been the comparable eating qualities of hatchery and

wild fish. At least one well-controlled investigation is available. Baeder and his associates (1948), by objective organoleptic tests scoring for aroma, flavor, texture, and moisture, gave significantly higher scores to wild trout than to hatchery trout. In 1950, Katz and Donaldson could show no difference in erythrocyte counts made on wild silver salmon fingerlings and hatchery fish. This is of interest because many methods in use with salmon differ considerably from those used with trout. Cooper and Benson (1951) failed to confirm the earlier observations of Klak, for they wrote:

Changes in condition subsequent to the first week after planting were slight for all species. Apparently the hatchery fish were able to adjust themselves to stream conditions and to compete successfully with the native fish for food.

Again the vitally important information on the hatchery life of the fish is missing. Haskell and his associates (1952) reported from New York data: "Length and weight data suggest that the growth rate of lake trout of Raquette Lake origin stocked as yearlings may be slower than the growth rate of trout from natural reproduction and fingerling stocking." Recent work from the Cortland (New York) Station has shown that the chemical composition of hatchery fish is markedly different from that of wild fish. This is particularly true of fat, which is influenced to a great degree by diet (Phillips et al. 1949, 1950). This work assumes a great potential significance when correlated with that of the Canadian researchers who have shown that the ability of goldfish to survive changes in water temperatures is correlated with the type of body fat (Hoar and Cottle 1952).

The conclusion that hatchery trout are "different" from wild trout can hardly be escaped. The basic reason for this difference is possibly economical. When management policies began to demand larger fish, the cost of artificial propagation shot up alarmingly. The emphasis in nutrition and disease research has, therefore, been placed almost entirely on developing methods for raising fish as cheaply and as quickly as possible. In addition, hatchery personnel have been universally judged on the number of pounds which they produced. There has been practically no effort to correlate our methods of artificial propagation with increased survival.

Pertinent to this discussion is a strange situation which has developed in relation to survival. The advocates of put-and-take fishing have developed the principle that the

terms "survival" and "recovery" are synonymous. If a hatchery fish is recovered from the stream by an angler, it has "survived." Anything which the researcher or fish culturist does to prolong the stream life of the fish defeats the purpose of management based on put-and-take fishing. This group contends that its policy represents sound business management: the higher the recovery of hatchery fish, the more efficient the business. In some respects this is true, but there are at least two fundamental considerations which invalidate the arguments against prolonging the stream life of the hatchery fish. The first of these concerns the recovery which is now obtained from put-and-take stocking. An average return of 50 percent is considered satisfactory. The fate of the other 50 percent is unknown. It would appear that these fish have been so far removed from their wild condition that survival is precluded for even limited periods. Here efforts to improve the hatchery fish would also improve the efficiency of put-and-take fishing. The second consideration involves the future of our streams. If we plant hatchery fish with no chance of survival, the resident populations may eventually vanish. We shall then be faced with complete dependence on artificial propagation. This is not our objective.

Our nutrition and disease laboratories have functioned very much like the agricultural experiment stations. The methods which they have developed have been aimed at producing livestock at a minimum of cost, in the shortest possible period. For the commercial producer of food fish, this is the desired end product. For the conservationist, it is not satisfactory. The criterion which must measure our success is stream survival. Until we attain that goal, our wild fishing will continue to disappear.

These concepts have not been ignored by our researchers. The lack of adequate facilities is the most immediate cause for the lack of progress in this direction. To correlate nutrition with survival, for example, it is necessary to have a test stream which is subject to absolute control. The most critical management area in our country today probably centers around the industrialized East; yet there are no available test-stream facilities in the eastern United States. Data from the 7,000-foot altitude of Convict Creek Station in California will not apply to a New Jersey stream. Nor will it be possible to transfer the data from the Hunt Creek Station in Michigan to Virginia. Similarly, information about Cultus Lake (British Columbia) salmon will do New Hampshire little good. Eastern

research will be handicapped until these facilities are available.

Hatchery techniques, too, need reappraisal. What are the effects of conditioning by increasing water flow? Is there any difference in planting on a falling water temperature or on a rising temperature? Does the addition of "new blood" result in anything but a reduced growth rate? Could the fish be made "wilder" by appropriate techniques? It is apparent that these questions also depend upon adequate test-stream facilities for their answers.

The future of our game fisheries will probably depend upon the compromises made between put-and-take management and management based on biological-environmental investigations. Both will be greatly advanced by an improved product from artificial propagation. When we have produced hatchery fish which can compete with wild fish in every respect, many objections to put-and-take fishing will be removed. A hatchery product of this type will also assure the survival of wild trout fishing. Such a product can be developed. It is unfortunate that this accomplishment has not already been achieved.

In summarizing the first year of Federal aid in fish restoration, King reported:

It will be apparent from a study of the projects currently in operation that new ideas in project types are not frequently encountered. ...

It is particularly noteworthy that of 112 projects in action last year, 76 were in the fact-finding category.

Yet if results are to keep pace with modern demands, if we are to secure the greatest possible benefit from the program, something more than an ordinary effort will be required. Long-range vision and sympathetic support, financial as well as moral, must be contributed by men at the administrative level. There must be an ever increasing number of the technical personnel whose thinking is characterized by curiosity, originality, and imagination. ...

--King, 1952.

The subject of our personnel difficulties in research was well discussed by Leonard. In regard to the lower salary range which is characteristic of the fishery field, he reported:

The net result of this situation so far as the administrator is concerned is that the bulk of the research on

which he is to base his policies will be done by graduate students and immature, unseasoned investigators. I by no means minimize the value of the work done by these young men ... but much more rapid advances could be gained if competent research men could be held, and their growing abilities kept in the research field ...

--Leonard, 1949.

Most of the administrators of current fishery management are cognizant of the necessity for a high caliber of research. The most recent example of this is the new salmon research laboratory which has been mobilized for the fight to rehabilitate the Lower Columbia watershed. In describing this laboratory, Coates and Woodall (1953) wrote, "These staff members will include a protein chemist, a lipid and carbohydrate chemist, an analytical chemist, a nutritionist, a histologist, a microbiologist, a fishery biologist, and laboratory aids."

A brief review of our 100 years of development has been attempted. Omission of names, important landmarks in progress, and dates has been unavoidable and is deeply regretted.

The words for our future were written 20 years ago by Seth Gordon (1933). They are as pertinent today as they were when written:

"We must set up research objectives. We need stocking standards. We need stream and lake improvement standards. We need better coordination of efforts. ...

"There are those among us who hold that we have about exhausted the field of fisheries research, and that we have learned all there is to know about fish culture. ...

"Then there are those who hold that our knowledge, based upon scientific research, is after all very limited, and that the surface has merely been scratched; that we are just beginning to learn how to handle large mass production in our hatcheries and to ward off the many diseases and enemies which have beset fish culture far too long; and that we must grow more and larger fish at public expense to restock our waters.

"But there is a much larger group which holds that ... the present supply of game as well as food fishes, is entirely insufficient to meet the rapidly increasing demands, and that it is high time the scientists, the fish culturists, and administrators and the laity pool their interests for the common good.

"... when big industries are up against it they redouble their laboratory efforts to

ascertain why, and to find new and better ways to do things. When public agencies are face to face with enforced economy they put a match to the laboratory, fire the staff and use the funds to build a bigger plant, hire more laborers or to try some new experiments ...

"It takes years of consistent effort to build up a scientific staff that's worth a hoot, and only a few hours to destroy the morale and to upset the whole program.

"Technically trained workers in public fisheries work are of comparatively recent origin, but they have so thoroughly demonstrated their usefulness that the trend in our public thinking is decidedly in their favor. This trend would be much more rapid if scientists would only remember to make their findings known in such simplicity that the general public could grasp the full significance of them."

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AN IMPROVISED MICROPROJECTOR

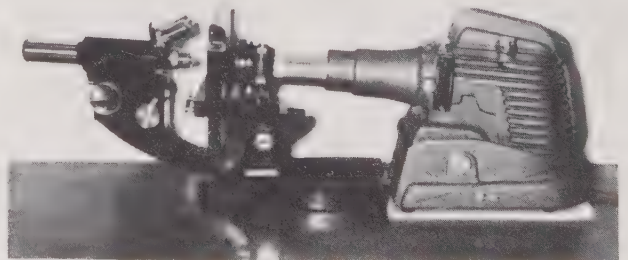
In the absence of more elaborate equipment, a standard compound microscope and a projector of the type normally used for projecting 35-millimeter Kodachrome transparencies have been used together to provide a very efficient microprojector.

To set up this improvised microprojector, the microscope should be inclined so that its optical system is in a horizontal position and the projector should be placed so that the projection lens is in line with and as close as possible to the substage condenser. (See photograph.) When the projector has been turned on and the slide has been placed on the microscope stage, various combinations of objectives and oculars may be tried until an image of the desired size and brightness is obtained. Depending on the wattage of the projection lamp and the combination of oculars and objectives used, a very satisfactory image may be projected for considerable distances.

Edwin P. Pister of the U. S. Fish and Wildlife Service reports that this arrangement of microscope and projector has been employed extensively by the fishery research biologists stationed at Convict Creek Experiment Station (Bishop, California), and that it has been especially good for the examina-

tion of trout scales. When there are trout scales to be examined, the microscope is placed 5 feet from the screen and a combination of 6X (22.7 millimeters) objective and 10X ocular is used. The illumination is provided by a 300-watt blower-cooled slide projector. With this arrangement, a field that is 3 feet in diameter is projected onto the screen and a trout scale that is only 2 millimeters long appears 26 inches long--a magnification of 330 diameters.

Although any smooth white surface will serve as a satisfactory viewing screen, a more brilliant and better-defined image will be obtained by using a standard, glass-beaded projection screen.



MORTALITY RATES OF BROOK TROUT AND BROWN TROUT IN THE PIGEON RIVER, OTSEGO COUNTY, MICHIGAN

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THE PIGEON RIVER TROUT RESEARCH AREA has been operated by the Michigan Department of Conservation, Institute for Fisheries Research, since April 1949. Here a 4.8-mile portion of the stream has been used to study some phases of the ecology of brook and brown trout. The present report deals with the mortality rates of naturally spawned trout, based on annual population estimates plus a complete record of the catch by anglers, and with the mortality of fall fingerling plantings of brook and brown trout of hatchery origin through 1 year of stream life. Native rainbow trout at present are too few to permit accurate estimates of mortality.

PROCEDURE

Annual mortality rates or survival rates of fish populations have been computed by investigators from the age composition of a randomly selected sample (Shetter and Leonard 1943, Schuck 1945, Ricker 1949, Allen 1951).

For the Pigeon River, estimates of the numbers of wild trout (i.e., excluding those of hatchery origin) in 4.8 miles of stream were made each fall with the use of electric shockers (Cooper 1952). These population estimates have been subdivided by year classes by use of extensive data on age and growth (Cooper 1953). Also, because of a change in fishing regulations in a portion of the research area, it has been advantageous to compute separate mortality rates for two different parts of the population. The mortality

rates were computed from estimated survival of individual year classes: this approach seemed advisable because there were large differences in egg production and in the resultant production of fingerlings from year to year and between different sections of the stream. It has been very difficult to obtain a sample of the trout population, unbiased as to age composition, by either angling or electric shocker.

Movement of trout between adjacent sections of the experimental portion of the Pigeon River, or out of these sections, has been demonstrated by marking experiments to be minor in extent (Cooper 1952). The pattern of distribution of the fish in different parts of the stream, as shown by repeated population estimates, also supports the view that we are dealing with fish populations that are quite sedentary.

A determination of the age of each trout caught by hook and line was made possible by the permit system of angling which was in effect on this portion of the Pigeon River (Cooper 1952). The data on fall population estimates and on age composition of anglers' catches were used to calculate the mortality of successive year classes of trout as a result of angling.

A direct estimate of the population of trout less than a year old (i.e., younger than fall fingerlings) was not made. However, the egg production was based on egg counts and estimates of the fall spawning population, and this gave some indication of the probable mortality rate of the trout during the first year of life.

In August 1951, a separate estimate was made of the number of wild brook and brown trout of the 1951 year class in section C, a 1.13-mile portion of the research area. During the operation the fish were fin-clipped for future identification. In October 1951, approximately the same number of hatchery

Contribution from the Michigan Institute for Fisheries Research.

Formerly in charge of the Pigeon River Trout Research Area, Dr. Cooper is now Chief Fishery Biologist with the Wisconsin Conservation Department.

fingerlings of the same age were fin-clipped and planted in the section to evaluate possible differences in survival between wild and hatchery fish.

EGG PRODUCTION AND FIRST-YEAR SURVIVAL

Direct evidence concerning the proportion of mature female trout in the fall population estimates of the Pigeon River is somewhat meager. Because extensive information of this sort would have meant the dissection of a large number of adult-sized trout, these data were deliberately not collected. To use the estimates of fall trout populations in the Pigeon River to compute egg production, it is necessary to rely on other sources for data concerning sex ratios, size at maturity, and egg production in relation to size. These data are summarized below.

In a compilation of collections from 15 different localities in Michigan, female brook trout constituted 55 percent of 1,712 fish over 1 year of age (Cooper 1949, thesis). Smaller collections of brown trout from the Manistee River and from the North Branch of the Au Sable River have been examined: the sexes were evenly divided--of 308 trout over 1 year of age, 154 were females.

Brook trout commonly mature at a smaller size and at a younger age than do brown trout. Mature female brown trout less than 3 years old have seldom been found in Michigan, but female brook trout of this age are commonly mature. Consequently, the bulk of the mature female brook trout are often smaller than the smallest spawning brown trout. Data on size and sex ratio of mature trout, from localities cited above, are as follows:

<u>Brook trout</u>				
Total length				
in inches....	5.0-5.9	6.0-6.9	7.0-8.9	9.0-10.9
Percent of females mature	62.5	88.9	96.6	100.0
Number of females.....	56	81	59	4

<u>Brown trout</u>			
Total length in			
inches.....	8.0-9.9	10.0-13.9	14.0-20.9
Percent of females mature.....	4.8	79.6	100.0
Number of females	42	54	29

Information concerning egg production of brook and brown trout has been assembled from many collections, since it is seldom practical to kill a large number of mature females from any one locality. Fish from the Pigeon River have been included in this compilation insofar

as data were available. The number of eggs in each female was determined by actual count, and the average values for successive inch-groups were adjusted by a moving average of threes to produce a smooth curve. Brook trout averaged a few more eggs than did brown trout of equal size, although the number of fish of comparable sizes was limited (table 1).

TABLE 1.--Egg production of brook and brown trout from Michigan

[Average number of eggs computed from moving average of threes]

Size group in inches	Brook trout		Brown trout	
	Number of females	Average number of eggs per female	Number of females	Average number of eggs per female
4.0- 4.9	38	104	-	-
5.0- 5.9	91	169	-	-
6.0- 6.9	59	268	-	-
7.0- 7.9	24	395	1	437
8.0- 8.9	15	525	0	488
9.0- 9.9	8	643	2	547
10.0-10.9	4	753	14	644
11.0-11.9	-	-	17	782
12.0-12.9	-	-	12	974
13.0-13.9	-	-	7	1,133
14.0-14.9	-	-	6	1,270
15.0-15.9	-	-	4	1,410
16.0-16.9	-	-	2	1,703
17.0-17.9	-	-	2	2,068
18.0-18.9	-	-	3	2,394
19.0-19.9	-	-	4	2,622
20.0-20.9	-	-	2	2,857
21.0-21.9	-	-	1	3,148
22.0-22.9	-	-	1	3,461

The data on sex ratios, size at first maturity, and egg production by size have been used in conjunction with the trout population estimates for the Pigeon River to calculate the egg production which resulted in the year classes of 1950, 1951, and 1952. Estimates of the number of fall fingerlings resulting from this egg production indicate a very low survival during the first year of life, averaging 3 to 4 percent (table 2).

The accuracy of mortality rates based on estimates of egg production may rightly be questioned. On the other hand, estimates of natural reproduction based on a count of redds, or on an estimation of free-swimming fry, are likewise of doubtful accuracy. However, the data suggest both that total mortality is high during the first year of life, and that this mortality varies from year to year. The causes for these survival rates' being variable between species and between calendar years are obscure, and explanations would be

TABLE 2.--Survival of fingerling trout from potential egg production in the Pigeon River

Year:	1950		1951		1952	
Stream sections:	A and B	C and D	A and B	C and D	A and B	C and D
Size limit:	7-inch	7-inch	7-inch	9-inch	7-inch	9-inch
Brook trout						
Number mature females present preceding fall...	98	431	216	637	236	950
Potential egg production.....	28,548	122,172	62,227	167,889	75,251	295,332
Number of fingerlings surviving.....	1,463	4,028	2,790	6,807	3,250	7,510
Percent survival.....	5.1	3.3	4.5	4.1	4.3	2.5
Brown trout						
Number mature females present preceding fall...	33	36	40	38	21	44
Potential egg production.....	29,286	31,844	36,395	31,882	17,543	35,548
Number of fingerlings surviving.....	884	737	599	431	1,011	1,309
Percent survival.....	3.0	2.3	1.6	1.4	5.8	3.7

highly speculative in the absence of further information.

MORTALITY RATES AFTER FIRST YEAR

In studies of fish populations and of mortality rates, a precise definition of terms seems necessary because of the lack of standardization among fishery workers at the present time. An excellent review and discussion of the nature of the terms "production," "stock," and "crop," as they pertain to fish populations, is given by Allen (1951). These definitions appear satisfactory and have been followed in the present report. Stock refers to the number of fish present at any one time, and crop is the same as yield to the angler.

Some individuals of both brook and brown trout populations in the Pigeon River reach legal size during their second year of life. During 1949 and 1950, a 7-inch size limit was in effect for all sections. During 1951 and 1952, the size limit was 9 inches in sections C and D. This change in size limit had the effect of excluding most of the yearling fish from the legal catch of 1951-52 (table 3).

The annual mortality rates for brook and brown trout in the Pigeon River are high, resulting in very few old fish in the population. Survival varies from year to year but is usually about 30 percent. Brown trout are somewhat more hardy than brook trout under the conditions encountered in this stream. The major portion of the second-year mortality cannot be accounted for by the legal catch, as the catch never made up more than 17 percent of the decrease in numbers from the first year to the second. Under a 7-inch size limit, the greatest contribution of any year class to the catch is made during its third season (figure 1). Also, a higher proportion of the mortality during this year, at least for the brook trout, is accounted for by the

legal catch. Under a 9-inch size limit in this stream, with no bait restrictions of any kind, a very small fraction of the naturally produced fingerlings carry over to the legal catch. It is not possible to make an estimate of the mortality of sublegal trout which were hooked and released by anglers, although it is possible that this factor might be a major source of mortality in heavily fished waters.

COMPARISON OF SURVIVAL OF WILD AND HATCHERY FINGERLINGS

During August 1951, an estimate of the 1951 year class of brook and brown trout in section C was made in conjunction with an attempt to fin-clip a large proportion of this year class in the stream. Starting on August 20, five trips were made through the section with a direct-current electric shocker and four independent estimates of the population were made (table 4). The rate of recapture of marked fish varied only slightly in the four recovery runs. Brown trout were a little easier to recover than were brook trout, probably because of the slightly larger size of the former.

In October 1951, 3,000 hatchery brook trout fingerlings and 300 hatchery brown trout fingerlings were fin-clipped and planted in section C. Survival rates to the following September indicate that the brown trout survive better than brook trout and also that wild fish are better able to survive than their hatchery counterparts under the same stream conditions (table 5). This better survival of wild trout over hatchery trout was also noted by White (1927), Hobbs (1948), and others.

The survival of the naturally spawned wild brook and brown trout of the 1951 year class which were fin-clipped was not much different from that of unmarked fish of the same year

TABLE 3.--Survival of trout in Pigeon River from number of fingerlings present

[Data given are the number taken during the year by anglers (crop) and the number surviving in the fall at the end of the angling season (stock). In parentheses under crop is the percentage of the catch in the decrease from one year to the next; in parentheses under stock is the percentage survival from number of fingerlings.]

fingerlings./			Calendar year								
Species	Stream sections	Year class	1949		1950		1951		1952		
			Crop	Stock	Crop	Stock	Crop	Stock	Crop	Stock	
Brook trout	A and B	1949	0 (0.0)	737 (100.0)	39 (14.0)	458 (62.1)	202 (46.8)	26 (3.5)	7 (31.8)	4 (0.5)	
		1950	-	-	0 (0.0)	1,463 (100.0)	169 (17.0)	468 (32.0)	117 (26.1)	19 (1.3)	
		1951	-	-	-	-	0 (0.0)	2,790 (100.0)	269 (11.2)	383 (13.7)	
		C and D	1949	0 (0.0)	3,623 (100.0)	73 (3.3)	1,398 (38.6)	36 (2.8)	120 (3.3)	6 (5.3)	7 (0.2)
			1950	-	-	0 (0.0)	4,028 (100.0)	3 (0.1)	1,898 (47.1)	47 (2.6)	105 (2.6)
			1951	-	-	-	-	0 (0.0)	4,995 (100.0)	7 (0.2)	1,140 (22.8)
	Brown trout	A and B	1949	0 (0.0)	646 (100.0)	24 (7.4)	320 (49.5)	73 (26.4)	43 (6.7)	3 (9.1)	10 (1.5)
			1950	-	-	0 (0.0)	884 (100.0)	99 (16.6)	289 (32.7)	26 (10.7)	45 (5.1)
			1951	-	-	-	-	0 (0.0)	599 (100.0)	71 (15.2)	132 (22.0)
		C and D	1949	0 (0.0)	817 (100.0)	26 (6.5)	419 (51.3)	29 (8.8)	91 (11.1)	4 (5.3)	16 (2.0)
			1950	-	-	0 (0.0)	737 (100.0)	0 (0.0)	545 (73.9)	24 (5.3)	89 (12.1)
			1951	-	-	-	-	0 (0.0)	276 (100.0)	1 (0.7)	141 (51.1)

Minimum size limits											
A and B		----	7 inches		7 inches		7 inches		7 inches		
C and D		----	7 inches		7 inches		9 inches		9 inches		

TABLE 4.--Population estimates of 1951 year class of brook and brown trout in section C, Pigeon River

Species and date	Number of fish caught	Number of marked fish present	Number of marked fish recovered	Percent recovery	Population estimate (stock)
Brook trout					
August 20, 1951	749	0	-	-	-
August 22, 1951	667	749	113	15.1	4,420
August 24, 1951	668	1,281	205	16.0	4,175
August 27, 1951	647	1,744	275	15.8	4,103
August 29, 1951	639	2,116	332	15.7	4,073
Total fish marked	-	2,423	-	-	-

Brown trout					
August 20, 1951	66	0	-	-	-
August 22, 1951	79	66	18	27.3	290
August 24, 1951	62	115	24	20.9	297
August 27, 1951	50	153	28	18.3	273
August 29, 1951	61	175	34	19.4	314
Total fish marked	-	202	-	-	-

class. Thus, fin-clipping could not be demonstrated to be a cause of additional mortality (table 5).

Various investigators (Shetter 1939, 1950; Surber 1937, 1940; Schuck and Kingsbury 1948; Schuck 1948; et al.) have shown that plantings

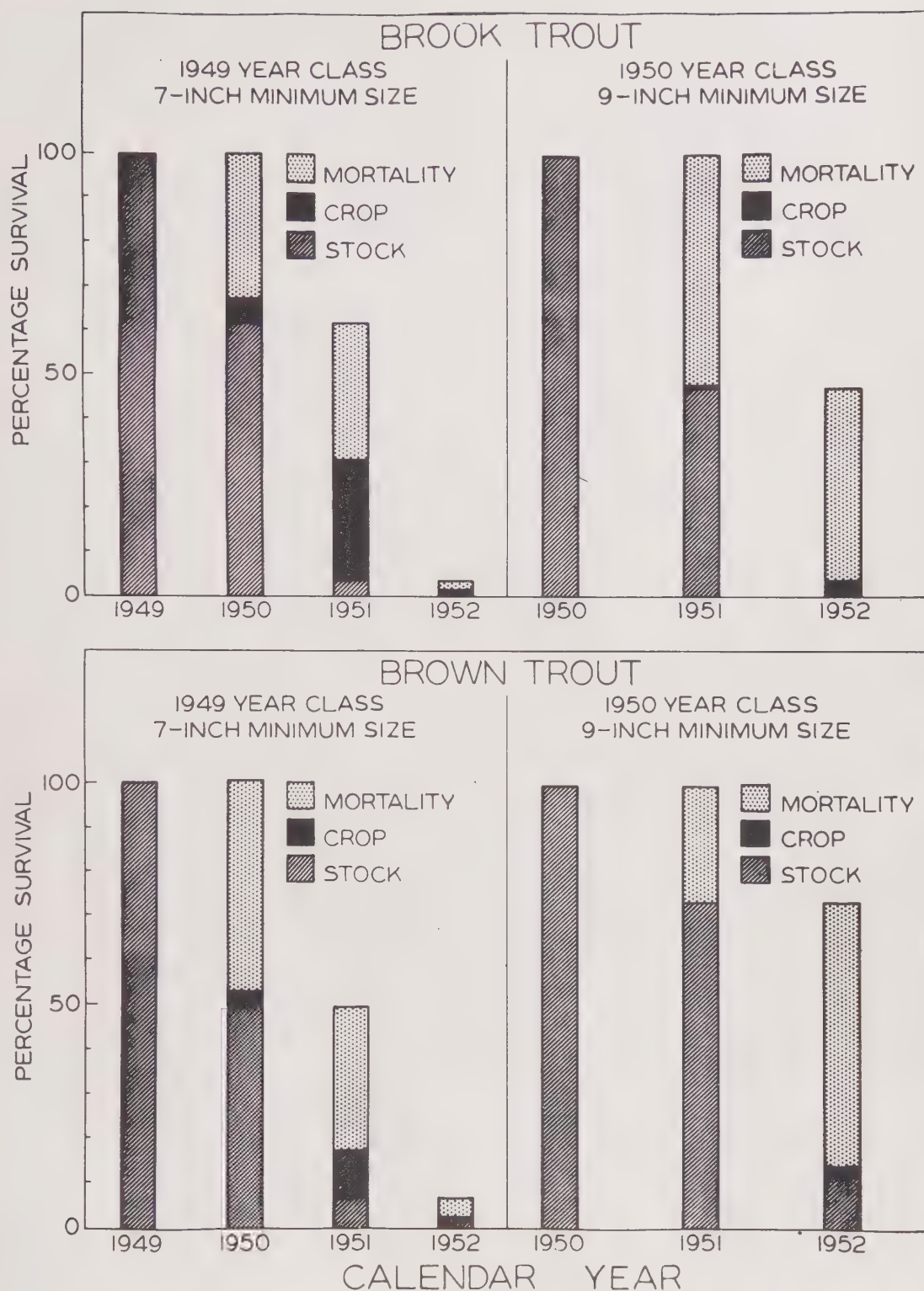


FIGURE 1.--Effect of legal-size limits on mortality, stock, and crop (angler harvest) of brook and brown trout in Pigeon River, Otsego County, Michigan. Based on part of the data in table 3. Data for the 1949 year class are from sections A and B; for the 1950 year class, from sections C and D. Percentage survival figures on stock are directly from table 3; percentage figures on crop and mortality are derived from data in table 3.

TABLE 5.--Survival of marked brook and brown trout of 1951 year class in the Pigeon River

[In parentheses is the percentage of survival of unmarked trout of 1951 year class in same stream.]

Date	Number of trout present			
	Brook		Brown	
	Wild	Hatchery	Wild	Hatchery
Aug. 20-29, 1951	2,423	-	202	-
Sept. 20, 1951	1,812	-	155	-
Oct. 5, 1951	-	-	-	300
Oct. 8, 1951	-	3,000	-	-
Sept. 22, 1952	329	92	65	66
Percent survival from fall of 1951 to Sept. 22, 1952	16.4 (19.6)	3.1 -	41.9 (30.8)	22.0 -
Percent of mortality appearing in legal catch	0.9	0.2	0.0	0.0

of fingerling hatchery trout give very low survival rates and yield very few fish to the creel. Needham, Moffett, and Slater (1945), Schuck (1945), and Needham (1949) also point out that the mortality of native trout populations is high, averaging better than 50 percent per year.

ACKNOWLEDGMENT

Special contribution of Messrs. Gerald F. Myers, Wayne H. Tody, and Norman G. Benson in all phases of the field and laboratory work is gratefully acknowledged. The study was supervised by Drs. A. S. Hazzard and G. P. Cooper, who also critically reviewed the manuscript.

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PLASTIC HATCHING JARS

A plastic hatching jar which was developed for private hatchery operators because of a shortage of the standard glass hatching jar is giving very satisfactory results, according to John Dobie, aquatic biologist of the Fisheries Research Unit, Minnesota Bureau of Fisheries.

The supply of minnows in public waters of Minnesota has not been large enough to meet the demand for bait fishes. Bait dealers have tried to relieve this shortage by raising in their ponds suckers of a size suitable for pike bait, and the Minnesota Bureau of Fisheries has supplied information on pond methods and fry for stocking ponds when necessary. In 1953 this program required about 100 million fry to stock the ponds with 40,000 fry per acre.

"The hatching of enough eggs in State hatcheries to supply that number of fry is a large job," writes Mr. Dobie, "that is complicated by the fact that 200 million walleye fry must be produced in the hatcheries at the same time. Several years ago the bait dealers realized the urgency of the situation and some built hatcheries of their own. The first to get started were able to buy chipped and partially broken jars from the State hatcheries, but that supply was soon exhausted.

"Inquiries to the glass companies showed that all jar manufacturers had discontinued jar production during the war and none intended to resume. Further inquiries disclosed that a plastics company in St. Paul would make a sample jar for trial at the Mounds Park Hatchery. The jar worked well but was too expensive. During the production of one small order,

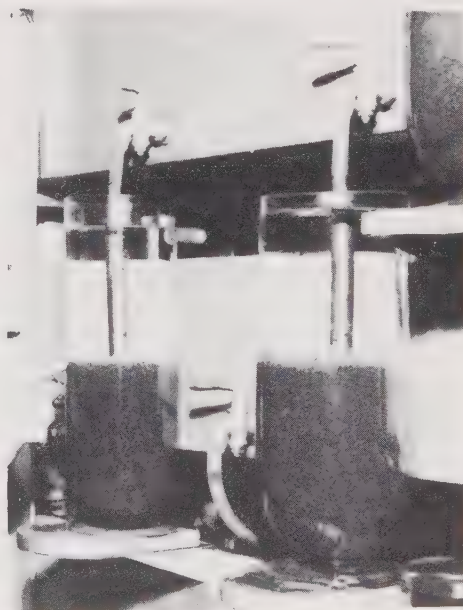
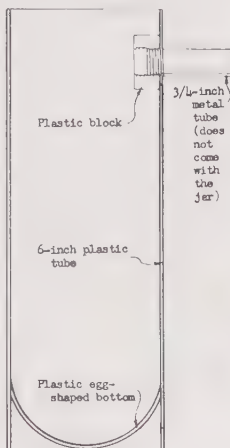
however, the company found a way to build the jar for half the price and at the same time improved the jar. This year five bait dealers bought enough jars for their hatcheries and the jars have proved so popular that many more dealers will be interested next year. Many glass jars will be replaced with plastic ones.

"The features that make the jar popular are the straight sides that allow the jar to stand close to the trough, a bottom so shaped that the eggs will roll no matter where the inlet tube is placed, an outlet threaded so that a pipe of any length can be inserted, and the light weight of the jar--a feature that should reduce breakage during handling and storage.

"Time will show how well this jar will stand up under years of use, but at present it looks like an excellent jar."

Plastic hatching jar (on left) and standard jar.

(Photo courtesy the St. Paul Dispatch.)



THE USE OF A GRAPHIC-RECORDING ECHO SOUNDER ON MAINE LAKES

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SYSTEMATIC BIOLOGICAL SURVEYS of Maine lakes were resumed during the summer of 1952. With the large majority of Maine lakes yet to be surveyed, all possible time-saving devices were considered. One of the most time-consuming parts of a survey is the manual measurement of water depths with a sounding line. Since many unsurveyed waters were of extensive area and were known to be relatively deep, any saving in the sounding operation would be especially valuable. As a step toward economy of time, a recording echo sounder was procured by the Fishery Research and Management Division in the spring of 1952. It was hoped that all sounding could be completed in early spring, prior to the summer survey season.

Echo sounders of the visual or dial type have been used by Burrows (1949) in Minnesota and by Stroud and Grice (1952) in Massachusetts. The use of a recording fathometer on inland waters has not been reported.

THE RECORDING FATHOMETER

The instrument used for sounding Maine lakes is a Raytheon Recording Fathometer Junior, Type 1373 SF. A permanent record of the bottom contour of each course traversed is made on moving graph paper by means of two recording styli. The chart moves at a rate of 30 inches per hour, and each chart roll lasts approximately 28 hours. This chart is calibrated in 2-minute time intervals, which are represented by equal spaces on the chart paper. Depths are recorded at the rate of 288 soundings per minute. Soundings are accurate within 6 inches when depths are less than 10 feet, and within 5 percent when depths are greater than 10 feet. The accuracy of the fathometer recordings was confirmed by periodic checks with a brass sounding chain on lakes during 1952.

The chart provides an accurate record of depths on one of three chosen scales: 2 to 200 feet, 2 to 400 feet, or 200 to 400 feet. The scale may be changed by shifting a lever inside the recorder case.

It is occasionally necessary to adjust the positions of the two recording styli to compensate for burning away of the stylus points and to ensure a minimum width zero-mark, sharp-edged echo recordings, and accurate soundings. Adjustments are made in accordance with the instructions provided with the instrument. The technique is perfected with experience.

BOAT MOUNTING

The recording fathometer is mounted in a 15-foot wooden boat (figure 1). The entire apparatus consists of four portable units, including a 6-volt, heavy-duty automobile storage battery. The battery is housed in a strong wooden box and rests in the extreme bow of the boat. The vibrator power supply unit, contained in a specially constructed plywood cabinet, is held in place on a small bow seat by means of three door hooks. The recorder unit is bolted to the right side of the center seat, where two occupants can easily watch the progress of echo recording. The transducer or "fish" is suspended 6 inches below the water level on the left side of the boat and is held in place by a single brass bolt through the gunwale. A hardwood dowel serves as a shear-pin and is secured through a small hole about 8 inches below the brass bolt. When obstacles are struck, even at full speed, the entire transducer assembly pivots harmlessly upward and backward.

The stylus points are set, according to the scale of the graph, 6 inches below the zero line to compensate for the depth of the transducer below the water level. Soundings



FIGURE 1.--The recording fathometer, mounted in a 15-foot wooden boat. Here are shown the recorder unit, vibrator power supply unit, and upper portion of the transducer assembly.

can thus be read directly from the chart without further correction.

The sounding equipment is normally operated by two men, a pilot and an instrument man. It would be possible to arrange for operation of all equipment by one man on small lakes where equipment could be driven to the edge of the water. However, in many cases it is necessary to carry the boat and equipment several hundred yards. A two-man crew is essential on large lakes as a safety measure.

In order to eliminate unnecessary jarring on rough roads, all equipment is removed from the boat while it is being transported between lakes. Unloading and assembling the equipment consume little time.

The vehicle employed for transportation of equipment and personnel is equipped with a battery-charger, permitting a battery to be charged while traveling.

THE SOUNDING OPERATION

During the sounding operation, straight lines are run between prominent landmarks at a constant rate of speed. The lines are marked carefully on an outline map, together with an arrow denoting the direction of travel. Distances from shore are noted at the beginning and end of each transect.

The "Record" or gain-adjustment knob controls the volume and intensity of the echo recording. In general, settings in the lower portion of the dial are desirable for depths less than 50 feet. More advanced settings are preferable for deeper water. An advanced

setting in shallow water often causes multiple echo recordings to appear.

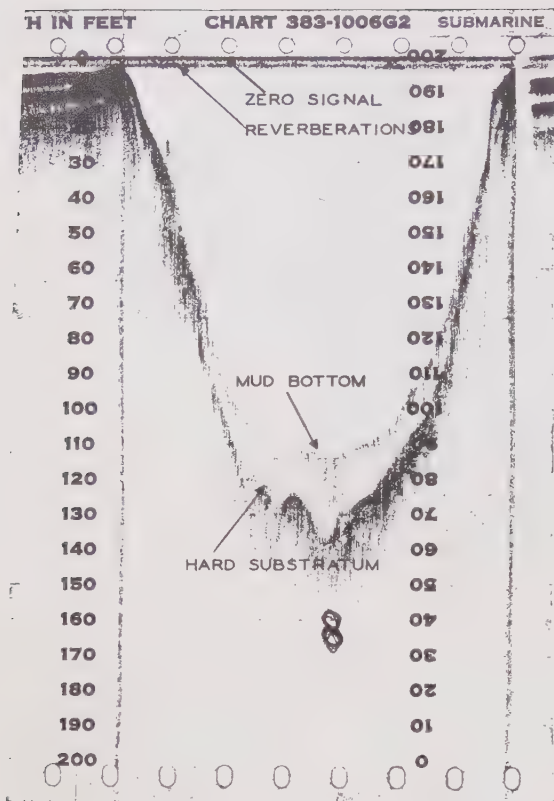
It is necessary to allow the instrument to "warm up" for about 1 minute after the "Record" switch has been turned on. The "Mark" switch, located on the recorder unit, is depressed at the beginning and end of each transect. This produces a dark line on the chart at the beginning and end of each transect (figures 2-5). The enclosed record is identified by a number, which corresponds to the line of the same number on the outline map. Transects are usually run with the outboard motor at three-quarters or full speed on large bodies of water and at slower speeds on smaller ponds. Slower speeds permit the charting of bottom topography in much more detail.

Graphic-recording of depths makes manual timing of soundings unnecessary. Results are recorded automatically as a fathogram, thus eliminating a source of human error.

The end result of the field work is an outline map marked with numbered lines and correspondingly numbered fathograms. The direction of travel and distance from shore are also noted on each transect line.

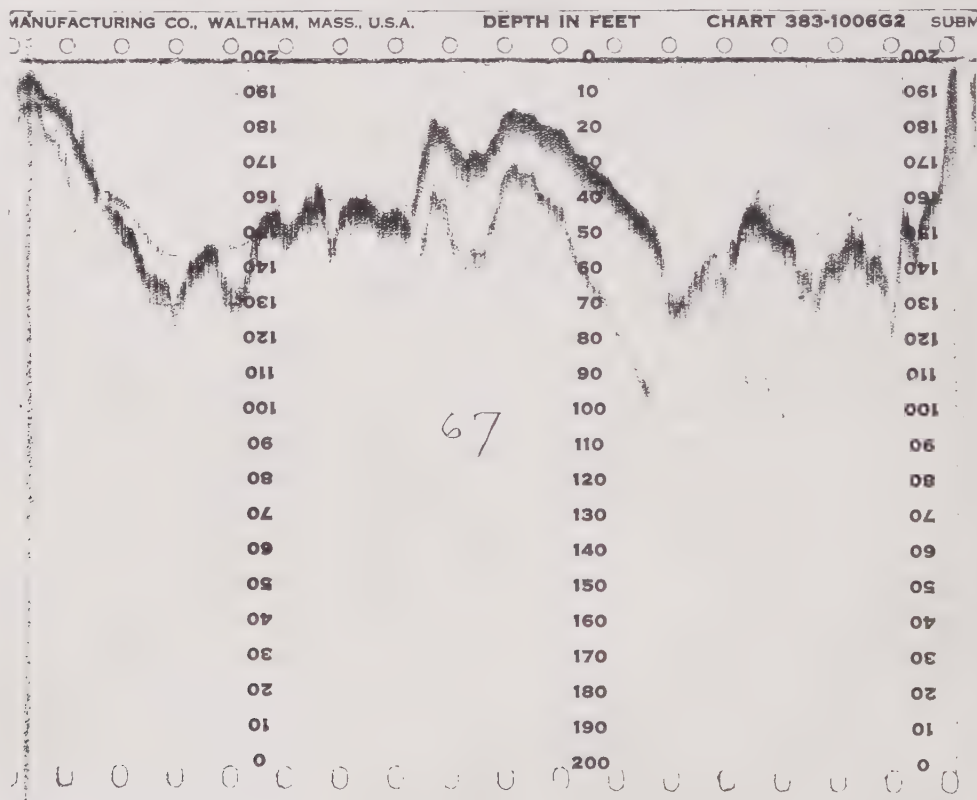
INTERPRETATION OF FATHOGRAMS

Certain precautions must be taken in the interpretation of recorded results. As previously mentioned, the "Record" knob is adjusted to a more advanced setting for deeper waters. Incorrect or imperfect gain adjustment may result in multiple echo recordings, and care



(Above)

FIGURE 2.--
Fathogram of a
typical deep-
water transect.



(Right)

FIGURE 3.--
Fathogram of a
transect showing a rocky
and irregular
bottom.

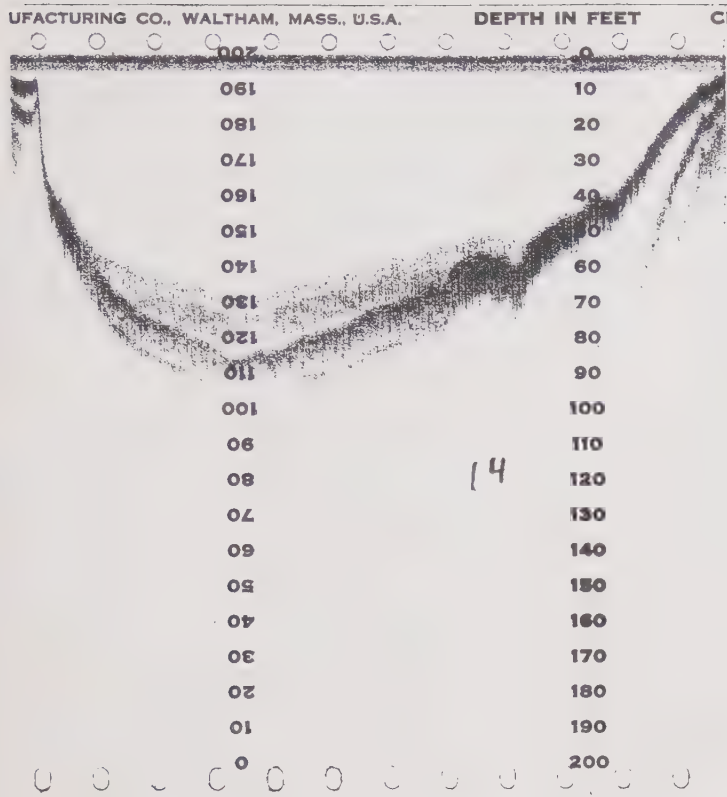
must be taken to assure correct interpretation of such records.

Characteristic echo recordings denote different types of bottom. Hard bottom may usually be recognized by a narrow dark record (figures 3 and 5); soft bottom is indicated by a wider light record (figures 2 and 4). Because of its low density, soft flocculent mud allows penetration of the signal and reflection from the hard bottom beneath.

Dense aquatic plant growth is occasionally recorded. Adams (1942) reports serious difficulties with kelp beds in marine waters. The source of these strays may almost always be discovered in inland waters, since they are usually caused by submergent pondweeds (*Potamogeton* spp.), which are quite visible in shallow water.

Records of shoals can usually be differentiated from those of aquatic vegetation by the inverted hollow cone appearance of the former. Traces of aquatic plants are usually solid in appearance.

Nondescript strays which cannot be attributed to any of the aforementioned causes are sometimes encountered. Adams (1942) found that such strays in marine waters were often caused by electrical noises in the sounding equipment or by the movement of the vessel through



the water. Checks with a sounding chain may always be made to verify the correctness of interpretation.

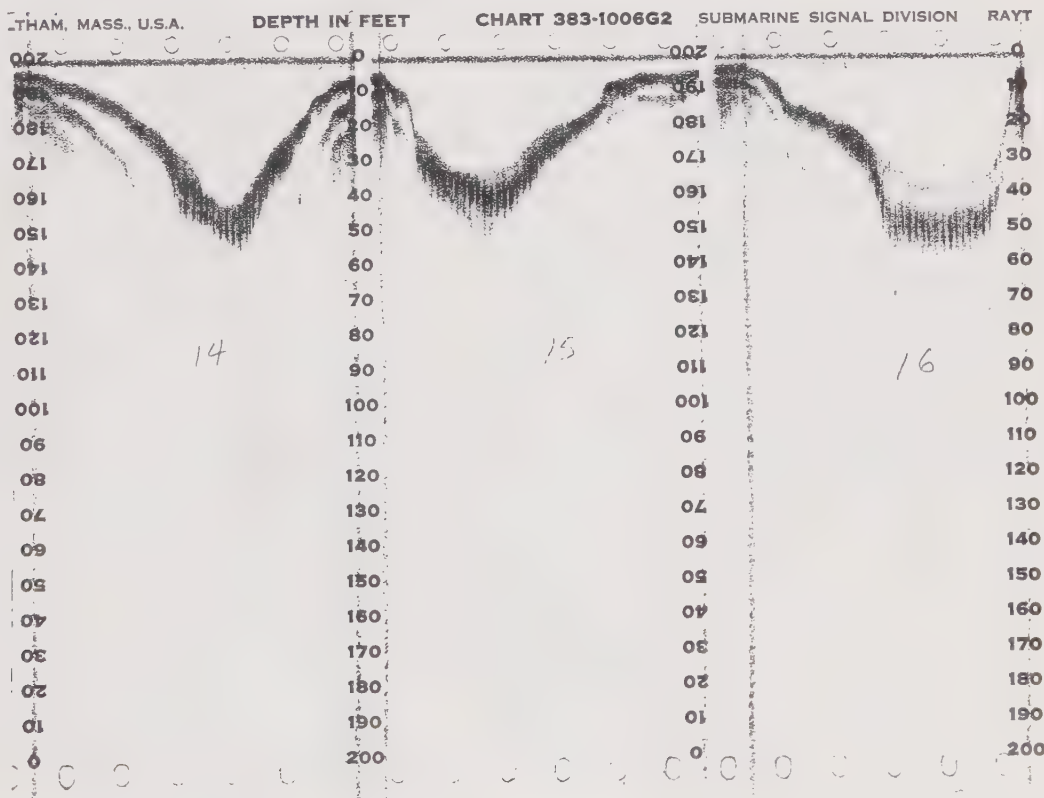
TRANSFER OF SOUNDINGS

Soundings are transferred from fathograms to the outline map of a lake. The outline maps are enlarged from United States Geological Survey topographic maps.

The first step, using the scale of the map, is to set off on each line of the outline map the distance from shore where soundings begin and end. Transect lines previously drawn on the outline map are then arbitrarily divided into equal intervals, the size of the interval depending on the frequency of soundings desired.

Then the length of the initial fathogram is measured. If the length of the record is 5 inches and the corresponding line on the outline map is divided into 20 equal parts, then soundings are set off with dividers 5/20 or 1/4 inch apart on the fathogram. Transfer of soundings is made

(Above)
FIGURE 4.--
Fathogram
of a
transect
showing
regular
bottom
contour
and mud
bottom
below 50
feet.



(Right)
FIGURE 5.--
Fathogram
of a
series of
shallow-
water
transects.

directly to corresponding points on the transect line of the outline map. It is apparent that as few or as many data as desired may be obtained from the fathogram of a transect. Some data must be discarded when transfer is made to the sounding map. The frequency of soundings transferred depends on the uniformity of the bottom contour as well as on the accuracy desired. The record of each transect is kept on file for future reference. Questionable cases may be reviewed in detail.

The method of transferring soundings from fathograms to the outline map may appear time-consuming at the outset, but the operation progresses with surprising rapidity with increased practice. For example, transfer of soundings on a 525-acre lake with 20 transects and a maximum depth of 102 feet took 40 minutes. Transfer of 232 soundings on a 1,747-acre lake consumed 1 hour, and only 10 minutes were necessary to transfer soundings on a 54-acre pond with 7 transects.

A graphic record of the bottom contour of a transect permits construction of a sounding map in great detail. Fathograms are particularly advantageous on large deep bodies of water and on those with irregular bottom topography. It is possible to locate precisely individual shoals and depressions.



AN AUTOMATIC SIPHON

To maintain a constant flow of fresh water into an aquarium and keep excess water from overflowing the sides, Leon D. Johnson of the Wisconsin Conservation Department recommends the automatic siphon devised in the laboratory at Spooner, Wisconsin.

Construction is simple, as it is necessary only to heat and bend glass tubing to the S-shape shown in the photograph, and then cut the intake end approximately 3/4 inch below the top curve. Tubing of 6-millimeter inside diameter apparently works best, though other sizes do almost as well.

When the siphon has been hung over the side of the aquarium, the water is turned on so that the tank will fill slowly. Reaching the intake of the siphon, the water builds up for a moment and then plunges down the tube, up the other side, and over the top bend--and so begins automatic operation.

Three or four siphons may be used if the water flow is uneven or a greater flow is desired.

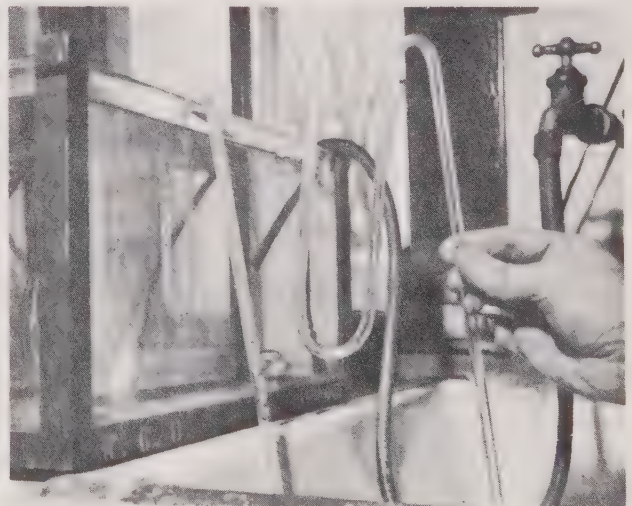
Accuracy is increased by actually recording a profile of each transect automatically, reserving transfer of soundings for the laboratory, and markedly reducing field duties of the sounding operators.

After a single season of use in Maine waters, it appears that the recording fathometer is the answer to Maine's survey sounding problem. An instrument of this type permits sounding operations to be completed in the spring, prior to the summer survey season. Thus, more surveys can be completed in the summer with a great saving in time and labor.

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Caution: The siphon should be changed and cleaned about every week, as it won't operate when dirty or slimy from algae or fish food.



A METHOD FOR CELLULOSE ACETATE IMPRESSIONS OF FISH SCALES WITH A MEASUREMENT OF ITS RELIABILITY

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DURING RECENT YEARS there has been a trend toward the use of cellulose acetate impressions of fish scales instead of the mounted scales themselves in age and rate of growth studies. Several difficulties have been encountered which cast doubt on the validity of the calculations made from impressions. Many presses either require excessive pressure or fail to record the thin edges of the scales on the plastic. When excessive pressure is used, there is a possibility that distortions may be introduced in the original impression or during subsequent storage. In order to minimize these difficulties, a press employing moderate pressure and considerable heat has been developed, and the reliability of calculations from the impressions has been checked in a series of experiments conducted over a 2-year period. Lea appears to have been the first to use scale impressions (Lea and Went 1936). Nesbit (1934), Merriman (1941), Greenbank and O'Donnell (1950), and Arnold (1951) have subsequently described various methods of making impressions. None of these workers, however, compared the calculations from the impression with calculations made directly from the original scales.

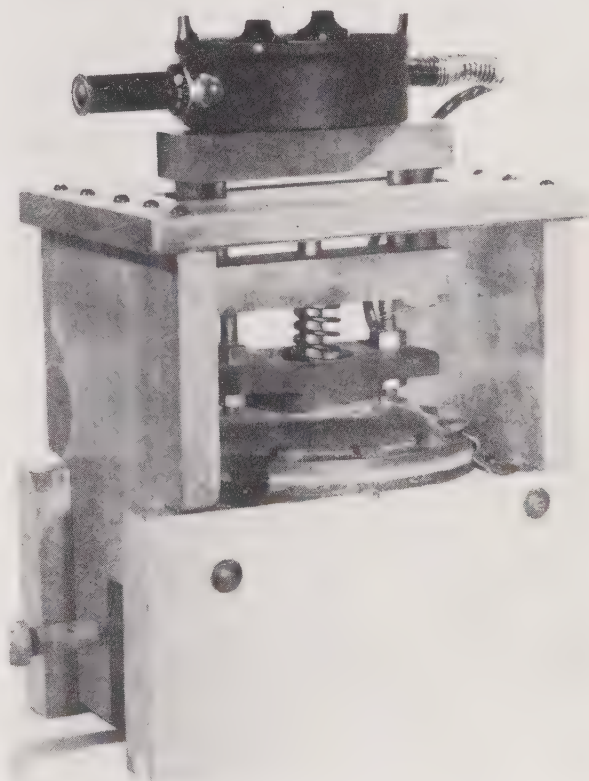
The Press

Since one of the principal advantages of the impression method is speed of preparation, it is important that the press be simple in operation and free from maintenance. A minimum number of required movements in operation and a high degree of fidelity in the transfers are essential.

To meet these needs, a pneumatic press was designed which could operate on the 80- to 100-pound air pressure that is available in

most laboratories (figures 1 and 2). The press consists essentially of a fixed jaw (A) and a movable jaw (B) which is activated by pressure from a diaphragm chamber transmitted through a pusher pin (D). As air pressure is applied, the diaphragm rises and moves the pin approximately three-eighths of an inch, which is sufficient to exert maximum force on the jaws. When the air is released

FIGURE 1.--Scale press completely assembled with thermostatically controlled heater in place.



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does not come in direct contact with pressure surfaces. The entire press is mounted in a wood frame or may be mounted directly on the work table. One of the principal virtues of the press is that it can be made at low cost; it is small and compact and requires no maintenance of any kind. There are only two moving parts, and no complicated or costly electrical adaptations need be incorporated. With 100 pounds of operating air pressure, approximately 1,200 pounds of pressure will be transmitted to the jaws.

Method of Operation

Cellulose acetate slides, 3 by 1 by 0.040 inch, are used to receive the impression. Plastacele, described in Technical Service Bulletin No. 22 of the E. I. DuPont de Nemours

through a three-way valve (E), the recoil spring (C) pushes the diaphragm down and permits the movable jaw to fall away from the fixed jaw. Heat is applied to the fixed jaw by inverting a small thermostatically controlled laboratory hot plate on its upper surface. During the preheat period, the jaws are held together; and after operation commences, heat is transferred to the movable jaw through the chromium impression plates described hereafter.

The diaphragm chamber is made from a salvaged high-pressure steam-reducing valve, and the diaphragm itself is made from cotton reinforced rubber of the type which is widely used in pressure diaphragms. The remainder of the press is machined from mild steel. Precision machine work is unnecessary, since the movable jaw is self-aligning and the plastic

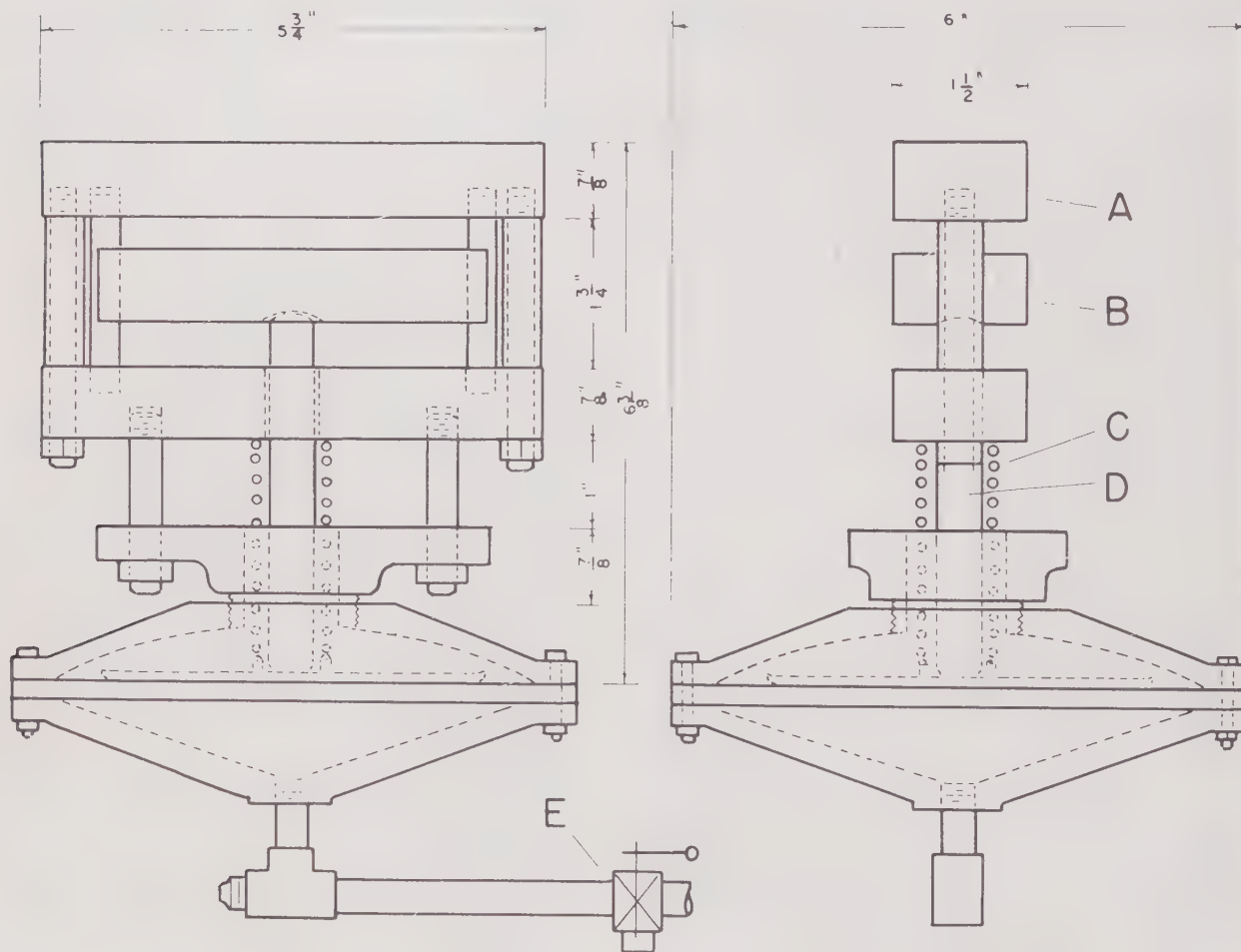


FIGURE 2.--Plan of pressure unit of scale press without mounting and heater: (A) fixed jaw, (B) movable jaw, (C) recoil spring, (D) pusher pin, (E) 3-way pressure control valve.

Company (Incorporated) Plastics Department, has been used for 3 years and has been completely satisfactory. When the humidity of the laboratory is very low, it is necessary to store the slides at a relative humidity of 50 to 60 percent and a temperature of 80° to 90° F. for several days prior to use in order to insure uniform quality of impression. When impressions are to be made, 4 to 5 scales are removed from a scale envelope and placed dry upon the slide with the sculptured surface down. The slide is then placed on a 3- by 4-inch chromium ferrotype plate and covered with a similar plate. After the jaws of the press have been heated to 400° F., the plates are placed between the jaws and pressure is applied for 40 to 50 seconds. The plates are then removed and put aside to cool. After 3 minutes, the differential cooling of the plates and the plastic permits the plates to be separated and the unwarped slide may be removed. Flexure of the cool slide will loosen the scales so that they may be removed undamaged. To avoid delay during the cooling period, 4 sets of plates are used in rotation. The employment of chromium plates is essential to the success of the process because they insure a perfect surface on the reverse side of the slide and also permit the use of temperatures which would otherwise cause the slides to adhere to the steel jaws of the press. Though plastic 0.040 inch thick is quite suitable for centrarchid and percoid scales, heavier scales may require slides as much as 0.080 inch in thickness. Since it is not necessary to clean the scales in order to get excellent impressions, an experienced operator can prepare 40 to 50 slides an hour with 4 to 5 scales on each slide.

Accuracy of Impression Method

The reliability of the impressions for use in growth calculations depends upon complete registry of the scale to the extreme edge and freedom from distortions in the entire impressed surface. To compare the calculations and measurements from scales mounted on glass

slides in glycerin-gelatin medium and impressions of the same scales on cellulose acetate, 3 typical scales were selected from each of 113 walleyes, *Stizostedion vitreum vitreum* (Mitchill). The scales from each fish were first placed dry between two glass slides and measured on the scale projector. Each set of scales was then impressed on Plastacele, and finally the scales were remounted on glass slides in glycerin-gelatin. Measurements were made on the central interradianal zone of the anterior field in both the plastic impression and the mounted scale. Several days after the mounting and initial measurements were made, a second set of measurements was taken.

One week after mounting, 13 sets of plastic impression mounts were placed in a 30° C. constant temperature cabinet and 15 sets were placed in a 5° C. cabinet. Eighty-five sets were stored at room temperature in the laboratory. Every succeeding 2 months for a 24-month period slides were measured along a marked interradianal zone from the focus to the anterior margin.

Comparison of the dry mounts and the impressions after the initial measurements showed that the total length of the impression was 1.1 percent shorter on the average than the dry scale. Similar comparison with the scales in glycerin-gelatin indicated that the impression was 3.3 percent shorter than the mounted scale. During the 2 years of storage the periodic measurements revealed no changes.

The shrinkage of the impression from the size of the dry scale results from a relatively large coefficient of linear thermal expansion for each degree Fahrenheit (4.8×10^{-5}). Larger size of the glycerin-gelatin mounted scale may be due to expansion from the moisture in the glycerin. The differences in size between impressions and mounted scales are not significant unless calculated lengths based on measurements from each type are different. A comparison of grand average calculated length at each annulus (Hile 1941) from the two types of mounts was therefore made in each of the three stored groups at the end of the 24-month period (table 1). The

TABLE 1.—The grand average calculated length of walleyes at each annulus as determined from acetate impressions and gelatin mounts of the same scales

Type of mount	Temperature	Number of scales	Annuli							
			I	II	III	IV	V	VI	VII	VIII
Acetate	Room temperature	85	2.92	7.49	10.53	12.76	15.03	17.39	19.98	-
Gelatin	Room temperature	85	2.91	7.51	10.53	12.75	15.00	17.40	20.00	-
Acetate	30° C.	13	3.79	7.18	9.66	11.66	14.22	16.99	17.65	18.94
Gelatin	30° C.	13	3.79	7.16	9.71	11.73	14.28	17.08	17.72	19.00
Acetate	5° C.	15	3.80	7.42	9.65	12.37	14.39	15.89	18.28	-
Gelatin	5° C.	15	3.85	7.42	9.66	12.41	14.40	15.88	18.33	-

TABLE 2.--The percentage difference in calculated length between the values obtained from the acetate mounts under different temperatures of storage and the comparable gelatin mounts at room temperature

Storage temperature	Annuli							
	I	II	III	IV	V	VI	VII	VIII
Room temperature	+0.34	-0.27	0.00	+0.08	+0.20	-0.06	-0.10	-
30° C.	.00	+.28	-.51	-.60	-.42	-.53	-.40	-0.32
5° C.	-1.30	.00	-.10	-.32	-.06	+.06	-.27	-

average difference in calculated length between any two types of mounts at any one of the annuli did not exceed 0.09 inch, a value less than the units (0.1 inch) of the original measurements. The maximum percentage difference between the values obtained from the cellulose acetate mounts stored at different temperatures and the comparable values of the gelatin mounts with one exception did not exceed 0.6 percent of the calculated length at each annulus. In the case of the first annulus calculation from the slides stored at 5° C. there was a percentage difference of 1.3, but it represented only a calculated difference of 0.05 inch in length at this annulus (table 2). The numerical differences which were calculated are believed to result from random variability in measuring scales rather than from actual differences in the types of mounts.

Conclusion

Although there are significant differences among the sizes of the original dry mounts, the gelatin mounts, and the Plastacele impressions, these differences are reflected proportionally at each annulus. Impressions which have been made in the manner described above and stored at temperatures within the 5° to 30° C. range may be used several years later with the assurance that the calculations on growth will be as valid as those made from the scales.

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Biologists of the U. S. Fish and Wildlife Service and the University of Washington are planning to undertake a study of the effect of low temperature on chinook (king) salmon eggs. For this study, it is proposed to obtain a number of lots of 20,000 eggs from streams in Alaska, Washington, and California, and then to hatch them in the Service's hatchery at Entiat, Washington. During incubation the water used would be progressively cooled to near-freezing temperatures and records would be kept of the mortalities occurring. The results from this experiment would be expected to indicate the degree of "acclimatization" of the chinook salmon throughout its latitudinal range.

AN EPIZOOTIC AMONG RAINBOW TROUT

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and
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RAINBOW TROUT (Salmo gairdnerii) from three localities in western Washington, submitted to us for examination during the last 3 years, have shown a characteristic disease. The pathology is produced by an organism apparently hitherto unrecognized in this area or in fresh-water fish in this country. An epizootic of serious proportions developed in one of the areas and is reported in this paper.

The agent that produces the disease is a spherical organism 10 to 80 microns in diameter occurring throughout the viscera, especially the kidney, liver, and spleen. We have assigned it to the genus Ichthyosporidium Caullery and Mesnil, 1905 (syn. Ichthyophonus Plehn and Mulsow, 1911).

LITERATURE SURVEY

During the last 50 years, organisms of this general group in European marine fish have been reported by about a dozen authors. There have been about the same number of reports from American marine fish and somewhat fewer from European fresh-water fish. The only reference to Ichthyosporidium in fresh-water fish in North America is that of Fantham and Porter (1948), who described organisms quite different from those we have seen.

Sproston (1944) gives an adequate review of the literature. To our knowledge, the most recent paper is that of Scattergood (1948). Robertson's figures (1909) of a disease in a small flounder and a haddock are typical of the parasite of the rainbow trout with which we are concerned.

* EPIZOOTIC

The infection in rainbow trout was brought to our attention in the spring of 1952, when excessive mortalities became apparent and the owner of a private fish farm sought aid. The farm contained about 20 dirt-bottomed ponds that ranged in size from 6 by 12 feet

to 40 by 100 feet. All were supplied by a common water source arising from springs in and around a brush-filled pond. The drainage through the fish-pond area involved many interconnections between ponds, so that very few had independent, previously unused water supplies.

The owner, who had purchased the fish farm 6 years before, had previously experienced no major epizootic of any kind. He had developed his own brood stock; so there was no introduction of fish from other areas. Two points of possible significance should be considered. In order to carry heavier loads of fish in the ponds, a large pump was installed in the lowest or last pond of the series and water was pumped to the head ponds for recirculation. Also, the viscera from fish cleaned for market were fed to the younger fish.

The losses, which were extreme in all ponds, varied. Although no definite records were kept, the owner estimated the losses on a percentage basis. The main loss was composed of the 2-inch fingerlings which were about 3 months old and the 6-inch fish which were slightly more than a year old. The losses in these groups amounted to about 90 percent. It is interesting to note that the larger fish in each pond seemed to become infected and die first. Later in the season, the 7- to 8-inch, 1½-year-old marketable fish and the brood stock which were about 3 or more years old suffered a mortality amounting to about 50 percent. In all, losses were estimated at 50,000 fish.

DIAGNOSIS

Fish that were in the early stages of infection showed no decrease in appetite or activity. At no stage was giddiness observed. As the disease progressed, the fish became sluggish, hovered along the banks, and sometimes could easily be picked up by hand. A darkening in color along the lateral line, later becoming universal, was quite common.

Swelling of the belly area as a result of hypertrophy of the viscera was also characteristic. The liver, spleen, and kidney were enlarged by the infiltration and development of the infectious agent in them. The organs were mottled with yellowish-white areas which extended deeply into the tissues. The infectious agent was found commonly in the spleen, liver, heart, kidney, stomach, intestine, visceral serosa, peritoneal exudate, gills, and rarely in the brain.

The organism as seen in a smear from an infected organ under the low power of the microscope is shown in figure 1. It appeared as spheres that were 10 to 80 microns in diameter, granular, opaque, and had a relatively heavy wall.

In fish that showed no gross changes of the viscera, only occasional microscopic fields contained the typical organisms. When advanced external or internal signs of the disease were present or when the fish had died spontaneously, direct smears of the liver or kidney revealed enormous numbers of the spheres. The multinucleate pattern of the organism could be seen only after treatment with a nuclear stain. The small spheres, which were usually seen in clusters, seemed to develop from the large spheres. Occasionally, especially in material held for a number of days, a germ tubelike extension was seen protruding from single spheres. This extension rarely was branched, but bifurcation was observed a few times. The length of the extension was about 3 to 8 times the diameter of the sphere.

TRANSMISSION

The disease has been maintained in rainbow trout in our laboratory by feeding the viscera of infected fish to healthy fish.^{1/} A mortality ensued after about 3 weeks, and the organism was found in the moribund and dead fish. This would indicate that the disease is transmitted per os, by eating infected material or

^{1/}Facilities for this work were furnished by the University of Washington School of Fisheries.

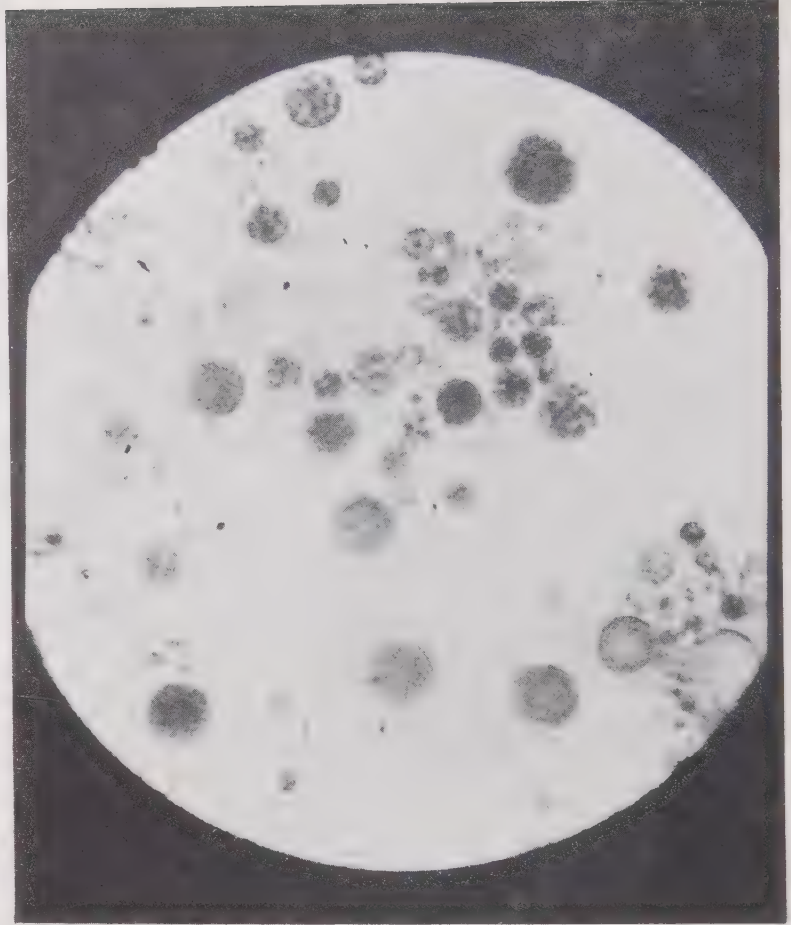


FIGURE 1.--Photomicrograph of a water mount of liver material from an infected rainbow trout. Granular spheres range from 10 to 80 microns in diameter. X100.

accidentally ingesting the isolated parasite. It would be easy for an infected fish to decompose and infect the surrounding water for a large area. The possibility that this disease could be introduced to a trout farm or hatchery through the feeding of infected ocean fish should be considered.

SUMMARY

An epizootic among rainbow trout (*Salmo gairdnerii*) in a private trout farm, resulting from a species of *Ichthyosporidium* that caused very high mortality rates in all ages of trout, reported from the State of Washington.

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CARE OF FISH PRODUCTS TO BE USED AS FOODS FOR HATCHERY FISH

In recent years fish and fishery products have become increasingly important as major ingredients in the feed supply for fish hatcheries in some areas. Material so utilized has included carp, buffalo, chubs, suckers, spawned-out salmon carcasses, salmon and tuna viscera, various ungutted ocean species, and the waste from processing plants. Visceral portions of some of the larger fish are excellent sources of most of the nutritive factors necessary for satisfactory fish growth and can be economically utilized. Charles Butler of the U. S. Fish and Wildlife Service has made a number of recommendations for the proper care of this material.

In order that fish flesh and viscera may retain the essential nutritive and growth factors at their maximum levels, this material must be promptly and adequately refrigerated. Decomposition from bacterial and enzymatic action, especially in visceral portions, can reduce the food stuff to a semiliquid, putrid-smelling mass in relatively few hours without refrigeration. Further, the deterioration will continue until the product is completely frozen. As spoilage action in fish continues rapidly at temperatures above the freezing range of fish tissue (30° to 25° F.), freezing should be completed as swiftly as possible.

Fish materials should be frozen at temperatures of -10° to -20° F. in an air blast or on contact plates where the refrigerant is at -30° to -40° F. Fish products should then be stored at a fairly constant temperature (preferably in the range of 0° to -10° F.).

As fish products placed in 40-pound tins or 50-pound wooden boxes will not freeze even

at -20° F. in less than 48 hours, it is desirable to use boxes and cartons about 24 by 12 by 4 inches in size to minimize the time required for heat removal. An excellent procedure is to freeze the products in shallow metal pans at low temperatures (perhaps -40° F.) in a blast freezer, follow with a water glaze, and place the material in a cardboard carton or close-fitting, tightly sealed kraft paper wrap. Boxes or packages should not be stacked in piles for freezing, although boxes or packages that have been frozen may be stacked if there is appropriate space for air circulation around, over, and under the stacks.

Materials may seem thoroughly frozen, but temperature should be regarded as the only safe measure of the protection afforded.

Any partly thawed lots of fish materials should be refrozen in the sharp freezer before being returned to the frozen-storage space.

It is generally accepted at modern hatcheries that a diet should be fed as soon as possible after preparation, and that meat or fish products once thawed and prepared for feeding should not be refrozen. Such dietary mixtures should be held in a room at temperatures just above freezing and should be fed to the fish not later than the day after preparation.

Where both fish and meat products are included in the diets for trout and salmon, these products should be kept separate until required for feeding the fish. At that time they may be mixed. This procedure is necessary because of the enzymatic action of fish products upon meat.

COLORED FISH-FOOD PELLETS

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THE CALIFORNIA DEPARTMENT OF FISH AND GAME, in an effort to keep the cost and availability of its trout hatchery foods in balance with its expanding catchable-trout program, has resorted in part to the use of pellet diets. The pellets are composed of various animal and vegetable meals and are manufactured to the State's formula by a commercial milling company.

The method of introduction of the pellets to the trout has posed a problem. During the early part of their lives, the fish are fed on meat diets; and when pellets are introduced, a training period is usually required. It has been noticed that fish in warm-water hatcheries (hatcheries with water temperatures above 54° F.) will accept pellets sooner than fish in cold-water hatcheries. Considerable waste occurs at some hatcheries even after the fish have become used to feeding on pellets. This is mainly due to the reluctance of the fish to pick up pellets which have fallen to the pond bottom. This last problem may be somewhat eliminated by slow and careful feeding, but in large production hatcheries such feeding is virtually impossible because of the time element.

At the suggestion of Mr. Lee Talbott, Assistant Supervisor of Fish Hatcheries, various food dyes were used to color pellets in the hope that some color might make them more appealing to the fish. Pellets were colored green, blue, yellow, and red. These colored pellets, together with some standard pellets (which are a light tan in color), were then fed to some catchable-sized rainbow trout (Salmo gairdnerii).

The fish reacted to the green, blue, and yellow pellets as they did to the standard, or uncolored, pellets: the fish ate some but allowed many to fall to the pond bottom, where they were then ignored. When the red pellets were fed, the fish reacted in the same vigorous manner as when they were fed meat. Con-

tinued observations revealed that rainbow trout which had never been fed on pellets showed a vigorous reaction to the red pellets but tended to ignore the other variously colored pellets. Further tests showed that red pellets were picked off the bottom, while the green, blue, and yellow pellets were not. It was felt from these demonstrations that it would be worthwhile for us to color our pellets red, thereby almost eliminating the training period and also reducing the amount of wastage.

It was found that we could color 100 pounds of pellets in a concrete mixer in about 5 minutes. This was done by adding $\frac{1}{2}$ ounce (about 12 cents' worth) of F.D.&C. Amaranth No. 2 [Food and Drug Administration's specification] red dye (powder form) and $1\frac{1}{2}$ gallons of water to the pellets in the mixer.

Since our concrete mixer would hold only about 25 pounds of pellets, we reduced the amount of dye and water proportionately. The dye was dissolved in the water and added to the mixing chamber of the concrete mixer, which contained the pellets. The mixer was then started and operated at a slow speed with the mixing chamber in such a position that the pellets fell at the top of the ride, thus insuring a good mix. In about 30 seconds the pellets were well colored and were then removed from the mixer. It was found that with our pellet formula no drying was necessary. It may be, however, that some experimenting would be necessary with other formulas (having a different moisture content) to determine the proper amount of water to be added; and in some cases air drying might be required.

Recently the California Department of Fish and Game has been notified that several milling companies would be willing to supply red-colored pellets. This would be of interest to larger hatchery operations, which find little enough time for food preparation without having to add another chore.

FURTHER OBSERVATIONS ON COLUMNARIS IN SALMON AND TROUT

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IN A PREVIOUS REPORT (Johnson and Brice 1952) we described an epizootic of columnaris which occurred in fingerling salmon and trout at the Dorena Dam Experimental Laboratory of the U. S. Fish and Wildlife Service at Cottage Grove, Oregon, during the summer of 1951 and the effects of water temperatures and treatments with sulfa drugs on the course of the disease. The experiments and observations that year led to the conclusion that sulfamerazine was partially effective in reducing mortalities from columnaris, but it was believed that the results would have been more convincing if treatments with the drug had been continuous during the warm-water period. The present report is a discussion of the experiments conducted during the summer of 1952, when sulfamerazine was fed for extended periods and further observations were made on the effects of water temperatures on the severity of the disease.

The general design of the experiments was the same in both years and has been described in detail in the first report. Spring chinook and silver salmon fingerlings were reared in circular tanks, 6 feet in diameter, and rainbow and cutthroat trout fingerlings were held in standard deep hatchery troughs. These tanks and troughs received water from three supply lines that had their intakes at three levels in Dorena Reservoir. Part of the water, hereafter called aerated, was passed through a large permanent aerator before being used; and part of the water was piped direct to the tanks and troughs and will be referred to as unaerated water. The aeration factor, which was part of another experiment, had no apparent effect on these disease tests and is disregarded in the evaluation of the results. In late spring a group of fingerlings of each species was divided into sections and placed in the various water supplies used in the experiments where rearing of the fish continued until fall. These supplies were: aerated and unaerated water from the lower hatchery intake, aerated and unaerated

water from the upper hatchery intake, and a mixed supply in which water from any or all intakes was used as necessary to maintain a temperature of 55° to 60° F.

The only drug used for disease control in the 1952 tests was sulfamerazine in the powdered form. This was fed to part of the fish of each species at the rate of 6 grams of sulfamerazine daily per 100 pounds of fish to be fed. The drug was mixed thoroughly with the feed, which was given to the fish in 2 portions each day, in the morning and in the afternoon. The salmon and trout received the sulfamerazine on 6 days of each week and were given neither food nor drug on the 7th day.

Water Temperatures

Weekly maximum and minimum temperatures of the water supplies used during the 1952 experiments are shown in figure 1. The temperature of aerated and unaerated water was the same for each supply. Water from the upper intake was cooler than in 1951 and did not reach maximum temperatures of 70° F. until in August, more than a month later than in the previous year. The temperature of this supply remained near 70° until the middle of September, when water was no longer available at the upper intake. The mixed water supply was maintained at the desired temperature of 55° to 60° until late in August. At that time the temperature of the water available through all of the hatchery intakes was higher, rising to a maximum of 68° when the last experiments were concluded. Water from the lower intake was the coolest supply used: the temperature remained below 60° until late August, when it, like that of the mixed supply, rapidly rose to a maximum of 68°.

Spring Chinook Salmon

Fingerling spring chinook salmon used in the tests were reared in 12 circular tanks.

As shown in table 1, mortalities were very low in all tanks and the type of water supply had no effect on the losses. The salmon in the 2 tanks receiving unaerated upper-intake water were fed sulfamerazine for a 10-week period from July to September without apparent effect on the mortality. In contrast with the record of the previous year, when spring chinook salmon seemed the most susceptible species handled, columnaris caused little or no mortality in these fish in 1952. The reason for this apparent immunity to the disease is unknown. The eggs were obtained at the same hatchery in both years; and though the temperatures of upper-intake water were somewhat cooler in 1952, this water was warmer than it had been at the time of the onset of the epizootic of columnaris in 1951. The disease was present in other species in the hatchery, and--as no isolation procedures were attempted--the spring chinook salmon were undoubtedly exposed to the causative bacteria. From this experience it is obvious that any predictions concerning the occurrence of columnaris are subject to much error.

Silver Salmon

Silver salmon fingerlings were also reared in 12 circular tanks during the summer of 1952. The percentage mortality in each tank is given in table 1. The losses were very low in the tanks supplied with lower-intake or mixed water, and there was no evidence of columnaris in the salmon reared in these tanks. Mortalities were also low in the 2 tanks receiving unaerated upper-intake water, tanks which held fish that were fed sulfamerazine for almost 12 weeks from July to October. The salmon in the 2 tanks supplied with aerated upper-intake water were given no disease treatments during the summer, and both tanks of fish suffered mortalities of more than 40 percent, primarily from a severe infection of columnaris. Infected silver

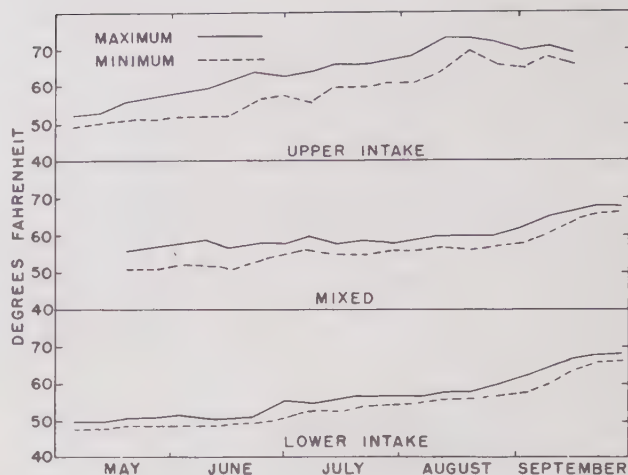


FIGURE 1.--Weekly maximum and minimum temperatures (in degrees Fahrenheit) of three water supplies, May-September 1952.

salmon first appeared in one of the tanks on August 10 and in the other tank on August 25, and mortalities from the disease continued at a high rate until all fish were released on October 1. Columnaris lesions were most commonly found on the body of the affected fish, near the base of one of the fins.

Rainbow Trout

The rainbow trout fingerlings used in these experiments were reared in 11 deep hatchery troughs. Mortalities during the summer are listed in table 1. Although somewhat higher than the salmon losses, the losses of these trout were not unusually high in the troughs supplied with lower-intake or mixed water; very few fish with lesions of columnaris were seen in these troughs at any time during the experiment. Only normal mortalities were experienced by rainbow trout reared in the 2 troughs supplied with unaerated upper-intake

TABLE 1.--Percentage mortality and sulfamerazine treatments in individual tanks or troughs of fingerling salmon and trout during summer of 1952

Species	Percentage mortality and sulfamerazine (S) treatment											
	Lower-intake water				Mixed water				Upper-intake water			
	Aerated		Unaerated		Aerated		Unaerated		Aerated		Unaerated	
Spring chinook salmon	1.5	0.7	1.1	0.5	0.4	1.4	0.7	1.8	0.7	1.6	0.7	2.3
Silver salmon	1.2	0.4	0.4	0.7	0.9	0.3	0.6	0.9	40.1	44.2	2.9	1.8
Rainbow trout	2.7	2.5	3.0	2.0	6.4	3.9	6.4	5.6	-	19.7	6.2	4.4
Cutthroat trout	7.9	2.5	16.1	2.2	4.9	0.9	2.9	2.1	-	46.5	6.0	2.8
											(S)	(S)

water. These fish were fed sulfamerazine for a 13-week period from June to September. There was 19.7 percent mortality in the trough of trout which received aerated upper-intake water and no sulfamerazine during the summer. Much of the increased mortality in this trough was caused by columnaris, which was present most of the summer but did not cause excessive losses until September (shortly before all fish were released and the experiment was closed). In the rainbow trout, the most common lesions of the disease were found at the base of the dorsal or caudal fins.

Cutthroat Trout

The cutthroat trout included in these experiments were reared in 11 hatchery troughs. There was considerable variation in the mortality in individual troughs supplied with lower-intake and mixed water. This variation was largely due to the appearance of columnaris in some of the troughs in September after water temperatures rose to 65° F. The disease would probably have caused higher mortalities in all troughs if it had been possible to continue the experiment past the closing date of September 18. The cutthroat trout in the 2 troughs supplied with unaerated upper-intake water were fed sulfamerazine at the 6-gram rate for a 10-week period from July to September. The losses in these troughs were considered normal, and very few fish with columnaris lesions were observed at any time. The fish in the single trough receiving aerated upper-intake water were given no dis-

ease treatments and suffered a mortality of 46.5 percent, chiefly from columnaris. The disease first appeared late in July, and the losses reached a peak 2 weeks later. There was then a rapid decrease in mortality, and there were no further losses from columnaris after August 25. The survivors apparently were not susceptible or had acquired immunity to the disease. Typical lesions of columnaris in the cutthroat trout were near the base of the dorsal or caudal fins.

Summary

Columnaris caused very little mortality in fingerling salmon and trout reared in water having maximum temperatures below 65° F.

Columnaris caused high mortalities in young silver salmon, rainbow trout, and cutthroat trout reared for extended periods in water having maximum temperatures above 65° F. Spring chinook salmon in this warm water were not affected.

Sulfamerazine, when fed continuously for 10 to 13 weeks during the warm-water period at the rate of 6 grams of drug per 100 pounds of fish, proved to be an effective control for columnaris in fingerling silver salmon, rainbow trout, and cutthroat trout.

Literature Cited

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1952. Observations on columnaris in salmon and trout. Prog. Fish-Cult. 14 (3): 104-109.



There is some evidence that electrical currents may be deleterious to the reproductive products of fish, particularly the eggs of salmon. Though there is no immediate cause for alarm, the possible effect of electricity on the reproductive ability of fish should be kept in mind by biologists and fish-culturists using electric shockers and electrical fish-guiding devices. The effect of various voltages, intensities, durations, and frequencies of electric shocks should be tested, not only on the ripe sex products in the adult fish but also on the developing eggs and sperm in fingerlings and young fish.

Though well-staffed laboratories of the U. S. Department of Agriculture, of State universities, and of agricultural experiment stations are doing much research on the diseases of all domestic animals, crop plants, and fruits, the research on fish diseases was until recently confined to two small Federal laboratories (each with but one biologist), two State laboratories, and the New York Aquarium.

DIVIDENDS FROM RESEARCH

RESEARCH ON CREEL-SIZE TROUT HAS INCREASED THE TROUT-STREAM ANGLERS' SPORT

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Trout fishermen are classified by some people as being slightly unbalanced mentally, but they still have the human trait of desiring the best possible return on their license investment in terms of sport. During the last decade, an increasing amount of sport has been provided for Michigan trout-stream anglers as a result of research on the creel-size (7 to 10 inches) trout used in the stream stocking programs.

Originally, most trout were released in the fall of the year after the closure of the regular trout season. This practice fitted in well with hatchery operation schedules; also, many sportsmen believed that a winter in the stream was necessary to make artificially reared trout more "wild" in character and appearance.

Failure of some of the earlier fall plantings of legal-size trout in Michigan streams to produce fishing of the expected quality led to more detailed tests of the best time to release these ready-to-catch trout. Since 1937, more than 65,000 jaw-tagged or fin-clipped trout have been released in streams in all parts of the State to determine the most advantageous time of planting so that the greatest number of planted fish will be recovered by the angling public. Where possible, recoveries of marked trout were obtained by creel census operations as well as by volunteer returns.

The main findings from these studies may be summarized as follows:

1. Six times more brook trout, four times more rainbow trout, and two times more brown trout were recovered by anglers from early spring and open season releases than were recaptured from comparable fall plantings of the same species.

2. Fall-planted trout did not distribute themselves over the stream appreciably more

than those planted in the spring, and the survivors were as vulnerable to the angler as were the spring-planted fish.

3. Plantings of brook trout and rainbow trout have given noticeably higher returns to the angler than have releases of equal numbers of brown trout.

4. Very few hatchery-reared trout survive to successive seasons: the number of survivors is generally less than 3 percent, rarely as much as 10 percent, of the original planting.

As a result of these findings, verified by repeated experiments in Michigan streams (and also in tests by many other trout-producing States), all stocking of creel-size trout in streams is now done in the early spring, just prior to the trout season, or during the open season. Recent intensive creel-census data from the Pigeon River Trout Research Station have shown that as high as 60 percent of such plantings may be recaptured by the anglers. In some of the more heavily fished waters near metropolitan centers of eastern United States, recovery percentages approaching 90 percent are said to occur. Where artificially reared fish must be stocked to provide the sport, there is little question but that spring and open-season releases have increased the sporting possibilities in comparison with that provided by fall plantings.

TAGGING THE "UNTAGGABLE"

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A chief enemy of the oysters of Long Island Sound is the common starfish. Oystermen estimate that in some years not less than 500,000 bushels of oysters are destroyed by these pests.

To control starfish, we needed to know a great deal about their behavior. For example, we needed to learn whether masses of starfish

showed seasonal migration from deeper to more shallow parts of the sound, and vice versa. It was also important to know how far a starfish could travel from the place where it was released.

In studying migration--or movements--of fin fish, a variety of tags has been successfully used. A review of all the models and their use was given us several years ago by Rounsefell and Kask.^{1/} In the case of starfish, however, the problem of marking was much more difficult because soon after a tag or other means of identification had been attached to the ray, the starfish would cast off this ray, together with the tag, and thus again become unidentifiable. Loss of the ray of marked starfish was of no help as an identification device, for many starfish in nature often lack one or several rays. This tendency of starfish to cast off members of their bodies if a foreign object was attached made the problem of marking rather difficult.

In 1935, after trying a variety of methods for marking starfish, we found a method which has proved to be easy, inexpensive, and practical. The method consisted of immersing live starfish in a weak solution of vital dyes, such as Nile Blue Sulfate. After being in this solution for several minutes, the starfish became greenish blue instead of their normal orange yellow. They were easily distinguishable in the collected samples, being as conspicuous, let us say, as a red egg in a basket of normal eggs. Some of these starfish that were recovered 10 months after being stained and released in Long Island Sound still retained the distinct greenish blue.

This method helped us to learn that starfish made no definite inshore or offshore migration during different seasons, and that the greatest distance traveled by any starfish was approximately 5,000 feet, or less than one nautical mile, in about a year. This information, of course, was very helpful in the project of devising methods of starfish control.

In those experiments where it was necessary to distinguish between individual animals, the method again was put to good use. Any portion of the starfish ray can be quickly stained by immersing it in a solution of Nile Blue Sul-

fate: the stain is localized in the immersed part. Thus, in some studies certain starfish had one blue ray and other starfish had two or three rays stained. These "mutants," as some people called them, together with the so-called Irish starfish, which were colored all over and looked somewhat green, created quite a sensation on the beaches of Long Island Sound about 20 years ago. Yet, they helped us answer many questions, and these answers helped the oystermen save their oysters.

THE ALBERTA WHITEFISH HATCHERY

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For many years the Alberta Government operated a whitefish hatchery. Each year 130 to 140 million whitefish were planted in various lakes as either "eyed" eggs or fry. It was generally believed that these plantings were essential in maintaining whitefish production. Several lakes which had not previously contained whitefish were stocked and developed into valuable whitefish-producing lakes. This proved that the hatchery products survived and supported the arguments that the plantings were necessary.

In 1941, the Alberta Government agreed to an experiment in which a series of seven whitefish lakes would be planted in alternate years: some lakes would be planted in the even years, the other lakes in the odd years. The purpose of the experiment was to determine whether the hatchery plantings had any effect on the commercial catch. Thus, if lake A was planted in 1941, it should yield a good catch of 5-year-old fish in 1946; whereas lake B, not planted in 1941, should yield a relatively poorer catch of 5-year-olds the same year.

This experiment was put into operation, and analyses of the ages of the commercial catch of whitefish from each of the seven lakes have been carried on each year to the present time. The data show conclusively that the hatchery has had no effect whatsoever on the commercial catches of whitefish. As a result of this research, the hatchery has been closed.

^{1/}Rounsefell, G. A., and J. L. Kask. 1945. How To Mark Fish. Trans. Am. Fish. Soc. 73 (1943): 320-363.



The drainage basin of Lake Superior extends over some 80,900 square miles.

EXCERPT TRANSLATED

LE BLACK-BASS EN FRANCE: ESQUISSE MONOGRAPHIQUE

Jacqueline Wurtz-Arlet
Annales de la Station Centrale d'Hydrobiologie Appliquée
Tome 4, pp. 203-286, Paris, 1952

This "monographic sketch" of the black bass in France touches many subjects: systematics of black basses; morphology; reproduction and development; food; growth; scale structure; culture and management; geographical distribution (in France). The paper is based both on personal researches of the author and on information gained from a thorough-going study of the literature. Here it may be mentioned that the coverage of American publications was excellent.

* Because so much of this paper covers matters well known to most American fishery workers, a detailed review does not seem to be desirable. It is believed, however, that most will be interested in the French point of view with respect to this introduced species as expressed in the following free translation of the final section, which contains the general conclusions and comments on the future of the black bass in France.

--Ralph Hile, U. S. Fish and Wildlife Service, Ann Arbor, Michigan.

The black bass, a centrarchid from America, was introduced into France about 1890. It seems that the two species known at the time, the largemouth black bass and the smallmouth black bass, were both introduced. Subsequently the works of American authors have shown that there are five species and ten subspecies. We have covered in detail the systematic position of the black bass, reviewing the numerous descriptions and the nomenclature and revisions that have created a certain amount of confusion and, following this historical account, have shown that all the specimens that we have seen in France belong to the subspecies, Micropterus salmoides salmoides (Lacépède) Bailey and Hubbs, for which we then gave the synonymy. We are concerned then with the largemouth black bass. To support this statement from a systematic point of view, we have presented extensive morphological data on black bass in France and have compared the distribution of the characters observed to similar data given by American authors. We have not seen the smallmouth black bass and have not obtained any evidence of its present existence in France. It seems that the acclimatization of this species was unsuccessful in our waters.

An important place is reserved in this paper for the biology of the black bass. Rearing this species in the ponds at the Station of Applied Hydrobiology at Paraclet, we have been able to make a large number of observations and to study in detail the reproduction of the black bass and the development of the egg and the young. The food of both young and adults was studied. The young at first feed on plankton. A small proportion of them become cannibalistic and grow more rapidly. The adult black bass is a versatile consumer of animal food. It is far from being as destructive of fish as is commonly believed. On the contrary, it feeds on all types of living prey: small fish, especially fry; insects and insect larvae; plankton; frogs and tadpoles; worms; and mollusks. It never preys on eggs of other fish.

Numerous observations were made on the growth of the black bass. In cold ponds the growth is poor. The most suitable waters are clear, with a spring and summer temperature between 15° and 22° C. The growth of the young is relatively rapid. It is possible to obtain in one summer young with a length of 10 to 15 centimeters [$\overline{3.9}$ to $\overline{5.9}$ inches] weighing from 15 to 60 grams [$\overline{0.5}$ to $\overline{2.1}$].

ounces⁷. Later the growth is less rapid--in two summers 200 grams [7.1 ounces], in three summers 400 grams [14.1 ounces], in four summers 750 grams [1.65 pounds], in five summers from 1,000 to 1,250 grams [2.20 to 2.76 pounds]; and it should require about ten years to grow a 5-pound black bass. The study of the scales makes it possible to establish the relationships among the age, the length of the fish, and the diameter of the growth zones of the scales. An important aspect of growth is the factor of robustness, described by a formula giving the relationship of length to weight, and otherwise known as fatness or embonpoint.

The culture of the black bass is relatively easy. In small ponds of moderate temperature and good biogenic capacity, and provided that roach are introduced as a forage fish and that we can count on exogenous food (insects, tadpoles), we can produce in one summer up to 10,000 young per hectare [4.047 per acre] with a length of from 5 to 12 centimeters [2.0 to 4.7 inches]. Rearing can also be carried on in spawning ponds and growing ponds. A combined production of black bass and carp is possible. Even the combination of black bass, carp or tench, and roach can be successful in sufficiently large ponds, yielding young of all species, a fact which proves that the black bass is not a voracious killer. Indeed, the bass serves more in the role of a balancing agent consuming quantities of superfluous small fry. The black bass further is of value in that it can prey on catfish [bullheads?]. The transportation of young or adult black bass offers no more difficulties than that of roach.

In France the black bass is acclimated principally in the southeast. It occurs in almost the entire basin of the Garonne, including its tributaries and canals; in a certain number of the coastal streams of the Atlantic--Charente, Sèvre-Niortaise and Marais Poitevin, Sèvre Nantaise; canals of southern Brittany; certain tributaries of the Loire, particularly the Thouet where it becomes very large; and finally in the Saône and part of the Rhône. In temperate waters the average size obtained is 3 pounds--occasionally but more rarely 5 to 7 pounds.

The fishery for black bass is most fascinating. All methods of fishing are effective: artificial fly, wet or dry; casting with a spoon or other lure; fish and all other live bait (frogs, insects), worms, crawfish, and shrimp; trolling with dead minnows ... provided only that the fisherman is skillful, for the black bass not only is voracious but is also a strong and shrewd fighter. In

pugnacity and resistance to capture, it is extraordinarily superior to pike and trout and comparable only to the salmon. The flesh is excellent, could even be termed tasty. Americans have long known this, and the gourmets of France are beginning to appreciate the fact.

The black bass seems then to have many fine characteristics.

Should the range of the black bass be extended? Shall we let our enthusiasm on this subject and our appreciation of the fine qualities of the fish lead us to say that it should be distributed generally?

Such a view cannot be supported. Our recommendations are much more restricted. We shall indeed make certain formal stipulations which we shall summarize as follows:

1. Black bass should never be planted in trout streams. First, its growth would be extremely slow in cold water. In addition, it would be a dangerous competitor of trout, since the food of the two fishes is closely similar. Introduction of black bass in salmonid streams would be disastrous.

2. We will now consider other types of waters, for example, cyprinid waters which are inhabited also by pike and perch. Here again we shall be arbitrary. The black bass should not be introduced into waters normally inhabited by pike and perch. To place these three predators together would be a great mistake. We must not forget that we have in France such indigenous fish as pike and perch which exist or should exist as normal components of balanced populations of rivers, and that the introduction of an exotic fish which would upset this equilibrium can be dangerous. The black bass should not be made a competitor of our pike and our perch either in natural waters or in ponds.

As a general rule, before we consider any new introduction, acclimatization, or replacement of a native by an exotic species, we should first exhaust all possibilities for the development and more effective use of indigenous forms. In natural pike waters where that species is declining, we should, before taking other steps, attempt to maintain and expand the stock of pike. We know that this is not always easy. In waters containing populations of dwarf perch, we should determine the cause of the stunting and attempt to remedy the situation.

We feel accordingly that the black bass should be introduced into open waters only when it has been determined that the biological equilibrium has been definitely upset and after all attempts at protection and restocking have failed to produce normal populations

of pike and perch. Under these conditions only, and even then under the indicated restrictions, can the black bass be considered as a fish to be introduced by reason of its greater angling interest, less voracious habits, and superior flavor as compared with the pike.

3. The most suitable waters for black bass are of moderate temperature, clear, and with little or no current. The rivers and canals of the southeast of France and the coastal streams of the Atlantic offer best examples. There are also many slowly flowing rivers, canals, cut-offs, and reservoirs in France where the black bass could be introduced, to the great delight of anglers and of those who like to eat fish, without the least injury to the existing biological equilibrium. The biological study of waters in advance of the planting of black bass is always advisable, for too many ill-considered plantings that were unsuccessful or even dangerous have been made. Up to the present, adequate precautions have been taken only rarely, and our final advice is for the exercise of careful judgment.

4. When it has been decided to stock a stretch of stream with black bass, it is best not to make small and scattered local plantings. We have seen that the black bass wanders extensively, and that every possibility

exists that fish planted at a particular spot may be recovered some 100 kilometers away. Those who have assumed the responsibility of stocking black bass in a particular region should not operate independently but rather should join in an integrated program of introduction.

5. In many ponds the presence of black bass is desirable and can provide an interesting fishery. The following precautions should be observed. The ponds should be so constructed as to leave no possibility of escape of the black bass from them. The waters should be clear and of proper temperature. The bottom by preference should not be muddy, and finally we should always avoid competition with the other predators, pike and perch. In carp ponds the presence of black bass can increase notably the annual production of marketable fish--for example, through the multiple culture of carp, black bass, and roach. Many larger ponds of several hectares and even certain impounded waters could be managed along the same principles of multiple culture. Here it should be possible both to have an intensive and attractive fishery and to increase the annual productivity. In this situation the black bass, despite its slower growth, shows incontestable superiority over the pike.



REPRINT

USE OF SODIUM AMYTAL ON FISH IN CALIFORNIA

Sodium amytal, a hypnotic-type barbiturate drug, may be used more widely on fish than on humans if a recent discovery of the California Department of Fish and Game is put into wide-scale use.

Twenty per cent of the 18,000,000 trout planted in California waters this year will be under the harmless influence of the drug when they are planted from tank trucks or airplane.

With a half grain of the drug to the gallon, only one-third to one-quarter the amount

of water is needed in transporting fish. Fish planting costs may be cut in almost the same proportion.

Where planting crews formerly carried 200 fingerlings to the gallon of water, the new system allows the transport of an average of 500 or more. Six- to ten-inch catchable-sized fish, once "canned" at eight to the gallon, may now be safely carried at 20 to the gallon or more.

The barbiturate calms the fish down to a point where they use less oxygen, and therefore need less water in transit. After many months of observation in captivity, once-drugged fish show no visible effects of their treatment.

Reprinted from Outdoor California 14 (27): 4-5. July 8, 1953.

Fish drugged and planted present no danger to the fisherman who catches and later eats them, Department announcement asserts.

California becomes the first State to use drugs in fish planting. Other States, as well as California, have used anaesthetic-type drugs successfully in limited live fish tagging operations.

Department Director Seth Gordon claims that the procedure is out of the experimental stage and will be widely used by the State next year.

Fishery workers have hailed the drug as an innovation as important to fish conservation as the development of the airplane planting procedure. And, the State's senior warden-pilot, Al Reese, is credited with the major role in both programs.

A veteran of 15 years of service with the fish and game agency, Reese deplored his summer task of carrying tons of useless water over the Sierra on the annual aerial fish planting mission. For the two and a half million trout planted by air in 1952, Reese and his pilots carried a total load of 25,000 gallons of water.

With the aid of a pharmacist friend, Reese experimented with the use of various types of drugs on the fish. After a dozen tries during months of experiments, the field was narrowed down to sodium amytal and seconal sodium.

Doses between one-quarter and seventeen grains to the gallon were used in the experiments. The latter proved fatal to the fish. Fish planting crews have since decided that the half-grain-to-gallon mixture is ideal.

When the fish hit the water after their ride by tank truck or airplane, the small amount of the drug in their systems becomes

diluted by fresh water and they immediately swim away.

In most cases, Reese states, drugged fish are in better than usual condition when they arrive at their new home--even after two-mile-high Sierra flights. The calming effect of amytal means less thrashing about in the planting cans and the piscatorial equivalent of a "rest cure."

The Department's marine fisheries workers are also looking over the possibilities of the drug on salt-water fish. Although no experiments have been carried out, hopes are high that it may be used in collecting live marine specimens for scientific use and aquarium display, tagging and transporting ocean fish for planting in the Salton Sea.

Proof of the effectiveness of the barbiturate is a recent truck trip between the Mt. Shasta state hatchery and Lake Merced, San Francisco, which lasted 19 hours. The 100,000 eastern brook trout were transported in one trip, an operation which would have required two trips without the drug. All fish arrived in good condition, and no casualties were noted.

In another instance, Reese flew 5,000 drugged smallmouth black bass fingerlings from the Central Valleys hatchery at Elk Grove to Blythe, on the Arizona border. Twelve pounds of drugged golden shiners, destined for planting in the Colorado River, also came through the three-hour air trip in good shape.

As the proof that Al Reese had a good hunch piles up in favorable fish planting reports, California inland fisheries people are looking toward new fields for use of the drug. Can it be used in the tagging and marking of live fish? Will it be effective in fish disease treatment or spawn-taking operations?



THE ENVIRONMENTAL HEALTH CENTER ANNOUNCES SCHEDULE OF TRAINING COURSES

Twenty-three (23) training courses in various aspects of environmental sanitation will be conducted by the Environmental Health Center of the Public Health Service at Cincinnati, Ohio, during the period July 1, 1953, to June 30, 1954. These short courses are given for professional personnel from State and local health departments, water pollution control agencies, the Public Health Service, other governmental units, educational institutions, and industries cooperating with these agencies in environmental sanitation programs.

The schedule includes advanced training in

chemical, bacteriological, biological and engineering aspects of stream and industrial waste surveys for water pollution control, and short courses dealing with special problems in water and industrial waste analyses, water supplies, sewage disposal, milk and food sanitation, radiological health, and occupational radiation protection.

A bulletin describing the 23 courses is available upon request from the Officer in Charge, Environmental Health Center, Public Health Service, Department of Health, Education, and Welfare, Cincinnati, Ohio.

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